EARLY TERTIARY OSTRACODA OF THE FAMILY TRACHYLEBERIDIDAE FROM WEST PAKISTAN

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EARLY TERTIARY OSTRACODA OF THE FAMILY TRACHYLEBERIDIDAE FROM WEST PAKISTAN

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CONTENTS

SYNOPSIS

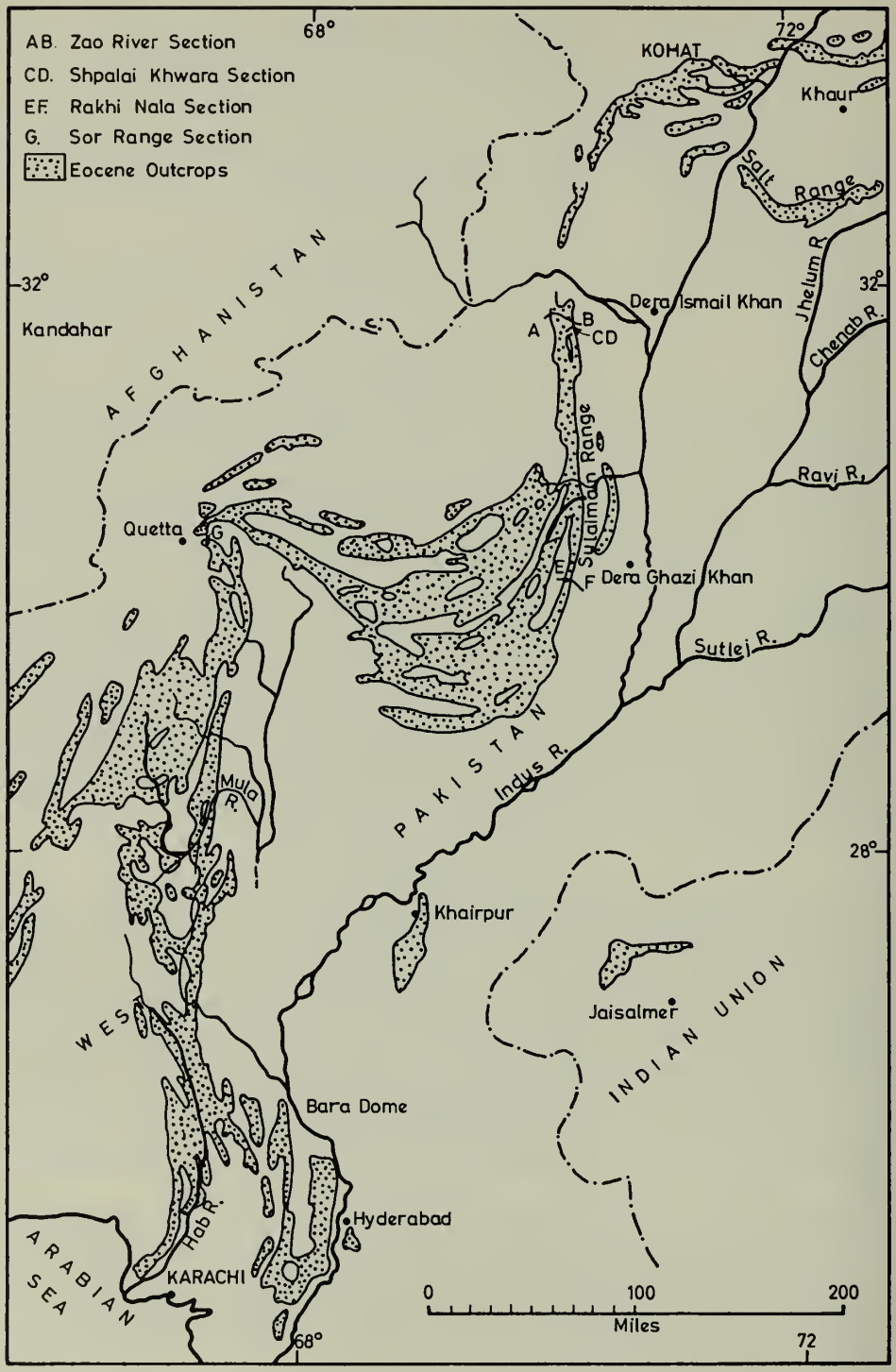
Ostracoda from the Palaeocene of the Sor Range and from the Palaeocene and Eocene of the Rakhi Nala, Zao River and Shpalai Khwara sections, Sulaiman Range, West Pakistan, have been examined. The family TRACHYLEBERIDIDAE has been studied in detail. It is represented by fourteen genera, four subgenera and fifty-nine species. Four new genera (*Alocopocythere*, *Gyrocythere*, *Phalcocythere* and *Stigmatocythere*) and two new subgenera (*Paracosta* and *Scelidocythereis*) are proposed. Out of the fifty-nine species described, fifty-four are new. Two species belonging to the genus *Phalcocythere* one from the Paris Basin and the other from Tanzania are also described.

The Palaeocene and Eocene of the Rakhi Nala section are divided into five ostracod biostratigraphic units. The biostratigraphic units IV and V of the Rakhi Nala are represented in the Zao River section and have almost identical ostracod faunas. The biostratigraphic unit IV of the Rakhi Nala is also represented in the Shpalai Khwara section. The Equations of Correlation between the Rakhi Nala and Zao River sections for biostratigraphic unit V (i. e. Middle-Upper Eocene) have been calculated by means of ranges of ostracod species common to the two sections. The standard errors of estimate for the Equations of Correlation have also been calculated. The boundaries between the Palaeocene-Lower Eocene, Lower-Middle Eocene and Middle-Upper Eocene in the Sulaiman Range are discussed.

1. INTRODUCTION

The most comprehensive work so far published on the area is that of Eames (1952 ab). Most of his lithological subdivisions for the Eocene succession of the Rakhi Nala and Zinda Pir areas occur in the northern Sulaiman Range, i.e. in the Zao River and Shpalai Khwara sections. These can easily be distinguished on the basis of lithology and microfauna. Eames' terminology of the rock units is therefore adopted here. Bayliss (1961) and Latif (1961 and 1964) are other recent workers who have contributed to our knowledge of the Palaeocene and Eocene in the Rakhi Nala section. However, they used a different terminology for the rock units to that used by Eames, and Fig. 2 shows the correlation between these workers along the Rakhi Nala section.

The samples from the Rakhi Nala section examined for ostracods were the same as used by Bayliss and Latif, who worked on larger and pelagic foraminifera respectively. These samples were collected by Bayliss. The sample numbers as given by the collector are used in this paper. Latif altered the sample numbers after 3200 by subtracting two hundred, i.e. his sample no. 3201 is the same as collector's no. 3401, and so on.



Outcrops of Eocene rocks of part of West Pakistan.
(After Eames 1952.) Sections described are indexed.
FIG. 1

Correlation between Eames, Bayliss and Latif along the Rakhi Nala

Eames (1952, p.162-163)					Bayliss & Samanta (in press)			Latif (1961, p. 33-36, 1964, p. 31)				
	*	Succession	Thickness in feet	Sample no. as used in present paper	Succession		Thickness in feet & sample nos.	Thickness in feet & sample nos.	Zones	Succession		
Upper Eocene	Tapti *	Pellatispira Beds	60	3666 3657	Kirthar	Mid-Upper Eocene	3666 2212 3453	110 3664 3651	Globigerina cf. trilocula	Chharat	Tapti	Middle Upper Eocene
		Upper Chocolate Clays (Upper part)	425-495	3656 3628				20 3650	Chiloguembelina victoriana			
								425 3644 3634	Hastigerina micra			
Middle Eocene	Kirthar	Upper Chocolate Clays (Lower part)	420-490	3627 3604				140 3623 3612	Chiloguembelina aff martini			
								170 3615 3607	Catapsydrax unicavus			
		White Marl Band	40	3603 3600				160 3606 3498	Globigerina yequaensis			
		Lower Chocolate Clays	930	3499 3478				900	No Pelagic foraminifera	Kirthar		
		Platy Limestone	70	3477 3474								
Lower Eocene	Laki = (Ghazij) **	Shales with Alabaster	750	3473 3439				100 3464 3460	Globorotalia sp. 3			
		Rubbly Limestones	410	3438 3413				1160 3459	Globorotalia sp. 4			
		Green and Nodular Shales	850	3412 3171	Ghazij	Lower Eocene	3607	670 3195 3166	Globigerina esnaensis	Ghazij		Lower Eocene
		Upper Rakhi Gaj Shales	1620	3170 3140			3140	1840 3165 3141	Hastigerina pseudoiota			
		Lower Rakhi Gaj Shales. (Topmost portion only = Irregularis Limestone.	60	3667 3668			3667 759 3116	30 3140	Globigerina sp. 5			
Paleocene	Ranikot	Lower Rakhi Gaj Shales (Max pars)	775	+3667-3672 3139 3116	Dunghan	* Paleocene		100 3143 3137	Globorotalia rex	Ranikot		Paleocene
								100 3136 3133	Globorotalia (T) crater			
								240 3132 3125	Globorotalia angulata			
		Gorge Beds	470	3115 3110	Ranikot		3115 553 3110	850	No Pelagic foraminifera			
	CARDITA BEAUMONTI BEDS †	Venericardia Shales	95									
UPPER CRETACEOUS		Pab Sandstones			Pab	UPPER CRETACEOUS			Pab			UPPER CRETACEOUS

* Probable equivalents of Eames, 1952.

** Eames, personal communication.

† Danian according to Nagappa, 1959, which he regards as basal Paleocene.

* ? Paleocene.

FIG. 2

Samples from the Zao River and Shpalai Khwara sections were taken by S. M. Ahmed and W. A. Zuberi and those from the Sor Range section by J. A. Reinemund.

All specimens with the prefix Io. are in the Department of Palaeontology, British Museum (Natural History). Those with the prefix GSP BM are in the Museum of the Geological Survey of Pakistan, Quetta.

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I should like to thank Dr. F. T. Banner (University College, Swansea) for examining some of the smaller foraminifera from the Rakhi Nala and Sor Range sections ; Dr. C. G. Adams (British Museum, Natural History) for his help in identifying the genus *Pellatispira* from the Zao River ; and Mr. J. A. Reinemund (U.S. Geological Survey) for the information on the Sor Range locality.

For the loan of samples, I am indebted to the following : Standard Vacuum Oil Company, Karachi ; The Director, Geological Survey of Pakistan, Quetta ; Dr. I. Strachan, Birmingham University ; Dr. D. D. Bayliss, Robertson Research Ltd. I would like to acknowledge the following persons for comparative material : Mr. E. S. Pinfold, Geological Adviser of the Attock Oil Co. Ltd. ; Dr. F. E. Eames, lately Chief Palaeontologist of the British Petroleum Co. Ltd. ; Mr. I. G. Sohn, U.S.A. ; Professor A. Wood, Aberystwyth ; The Director, Oil and Gas Commission, India ; Dr. W. A. van den Bold, U.S.A. ; Dr. W. D. I. Rolfe, of the Hunterian Museum, Glasgow ; Dr. N. Grekoff, France ; Dr. R. C. Whatley, Aberystwyth ; Dr. J. E. van Hinte, Holland ; and Professor G. Ruggieri, Italy.

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III. LITHOLOGICAL UNITS

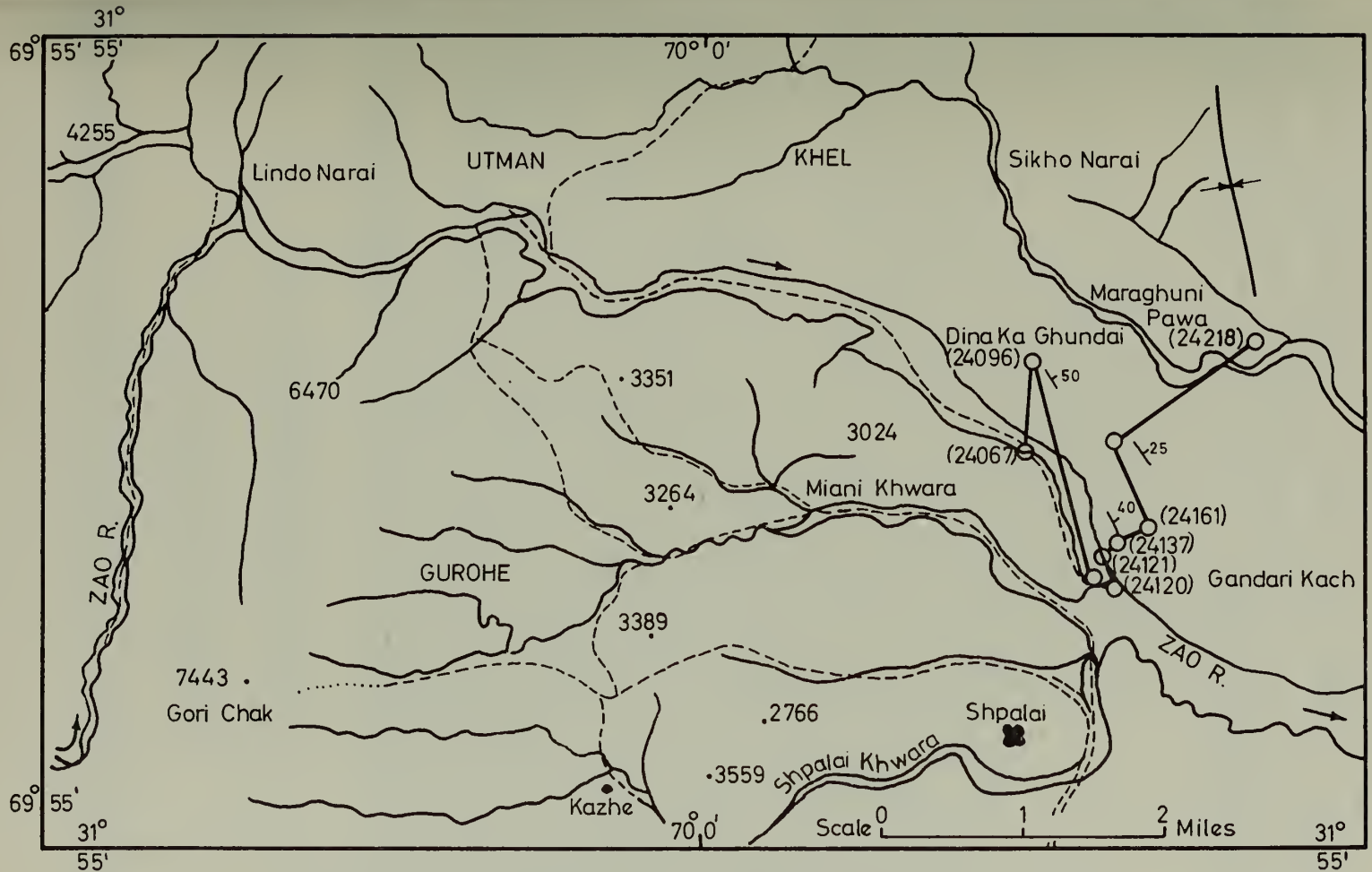
Sulaiman Range. The lithological units of the Rakhi Nala section have been described in detail by Eames (1952, pp. 162–165), Bayliss (1961) and Latif (1961, p. 32). Fig. 2 shows the succession, and the formation names give some idea of the lithology ; for a fuller description, see the authors mentioned above. The Eocene succession in the Zao River and Shpalai Khwara sections (Fig. 3) is very similar to that of the Rakhi Nala section. A detailed lithological description of rocks exposed along the Rakhi Nala, Zao River and Shpalai Khwara sections is given by means of two charts.

		Succession	ZAO RIVER Thickness in feet	ZAO RIVER Sample nos.	SHPALAI KHWARA Thickness in feet	SHPALAI KHWARA Sample nos.
Upper Eocene	Upper Kirthar (= Tapti of Eames)	Upper Chocolate Clays (Upper part)	1796	24210 ↑ 24161	NOT EXPOSED	
Middle Eocene	Lower Kirthar (Kirthar ss. of Eames)	Upper Chocolate Clays (Lower part)	910	24160 ↑ 24138		
		White Marl Band	86	24137 24134		
		Lower Chocolate Clays	754	24133 ↑ 24120		
		Platy Limestone	178	24119 24114	40	24696 24694
Lr. Eoc. (U.pt)	Ghazij (U.pt)	Shales with Alabaster	at least 332	24113 24097	at least 320	24693 ↓ 24675

Part of the Eocene Succession in the Northern Sulaiman Range.

FIG. 3

Sor Range. Samples were collected from the " Claystones " which are overlain by fifty feet of conglomerates. The Ghazij Shales overlie the conglomerates. A chart showing these lithological units is given (Fig. 6), and a detailed succession is given in Appendix 1. " The locality is in Lease 58 on the north slope of the Sor Range, about eight miles by road east of Quetta (Survey of Pakistan Topo.Sheet No. 34 N/4, co-ordinates 30° 11′20″ N., 67° 10′ E, grid reference P 125210). Samples were collected from a road cut along the main access road that crosses the lease approximately parallel with the outcrop and along the contour of the slope ; structurally the locality



Map of the Zao River and Shpalai Khwara sections.
Numbers in brackets refer to samples. (After Ahmed & Zuberi)
FIG. 4

is near the northern end of the Sor Range syncline, which is the major structural feature of the Sor Range-Danghari coalfield." (Reinemund, personal communication 1966).

Dr. F. T. Banner of University College, Swansea, was kind enough to examine smaller foraminifera from sample 460-i. He has dated this horizon as the Upper Palaeocene (*pseudomenardii* Zone).

IV. SYSTEMATIC DESCRIPTIONS

Subclass *OSTRACODA* Latreille 1806

Order PODOCOPIDA Müller 1896

Suborder PODOCOPINA Sars 1866

Superfamily ***CYTHERACEA*** Baird 1850

Family ***TRACHYLEBERIDIDAE*** Sylvester-Bradley 1948

Diagnosis. Cytheracea with heavily calcified carapace, often highly ornamented with more or less conspicuous eye-tubercle. Muscle scar pattern basically consisting of four adductor scars (one or more vertically divided in some genera) with a frontal scar which may be simple, V-Shaped, U-shaped or multiple. Posterior characteristically sub-triangular or auricular, but in some genera produced to form a caudal process. Subcentral-tubercle present or absent.

Remarks. The classification adopted here is to retain the trachyleberids and the hemicytherids in the family Trachyleberididae. Although in general trachyleberids possess a subcentral-tubercle and a V-shaped frontal scar whilst hemicytherids possess divided frontal and adductor scars, an auricular posterior end but lack the subcentral-tubercle there still remain a large number of genera which tend to overlap, thus making it impossible to clearly define the groups at the present time. Hazel (1967) identified two families, the Trachyleberididae having six podomeres in the antennule and the Hemicytheridae with five podomeres. This morphological character is useless palaeontologically and considering the number of trachyleberids which share hemicytherid characters (e.g. divided frontal scars) and hemicytherids having a subcentral-tubercle it would appear optimistic to expect the number of podomeres in the antennule to be so unique as to be restricted to only one group when other, equally good morphological characters obviously are not.

Pokorny (1964) considered the Hemicytherinae to be a group having a horizontal classification, and the situation at the present time has not been effectively clarified.

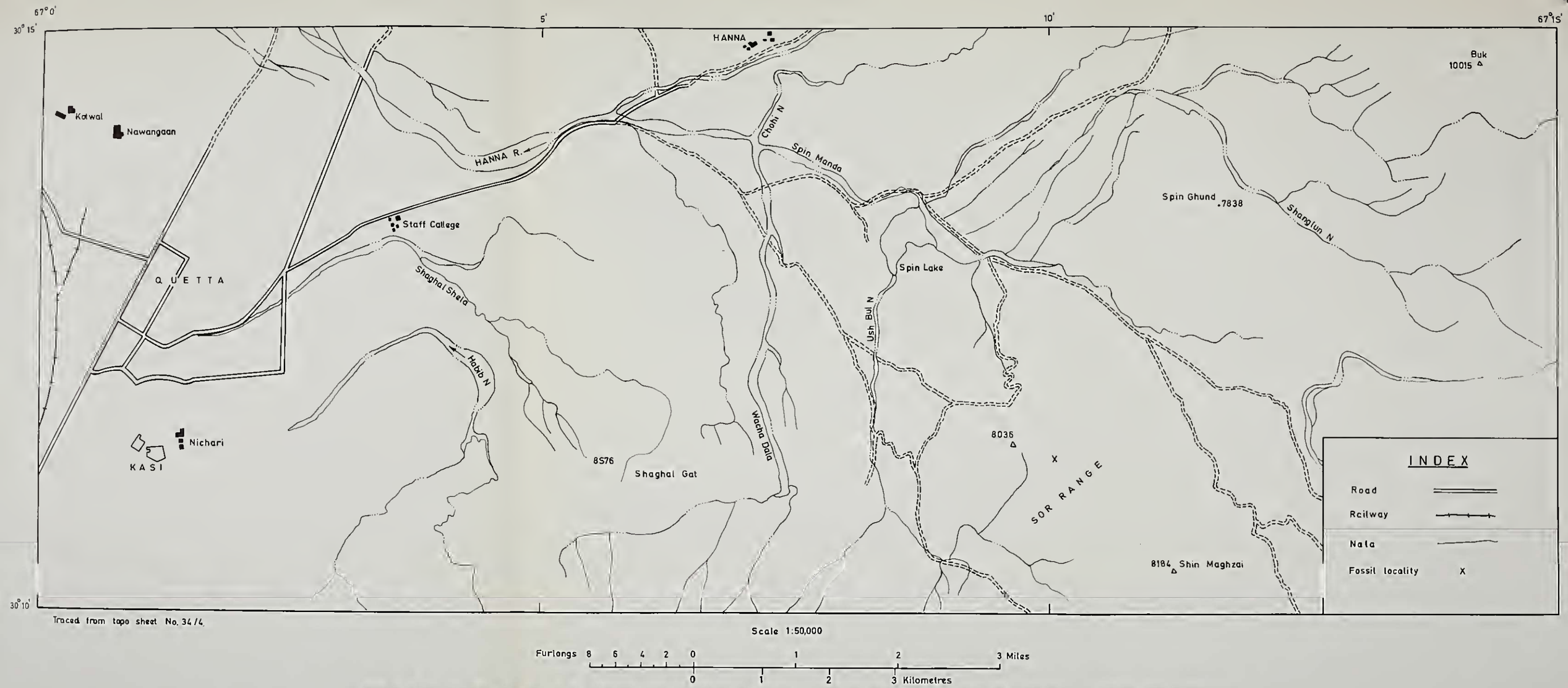
Genus ***ACTINOCYTHEREIS*** Puri 1953

Type species. *Cythere exanthemata* Ulrich and Bassler 1904

Actinocythereis? quasibathonica sp. nov.

(Plate 1, figs. 1–3, 6, 7, 10–13)

Derivation of name. Latin *quasibathonica*, "simulating Bathonian"; with reference to the resemblance to the Middle Jurassic (Bathonian) genus *Oligocythereis*.



MAP OF PART OF SOR RANGE SHOWING FOSSIL LOCALITY, QUETTA DIVISION, WEST PAKISTAN.

FIG. 5

SOR RANGE SECTION

Measured by John A. Reinemund

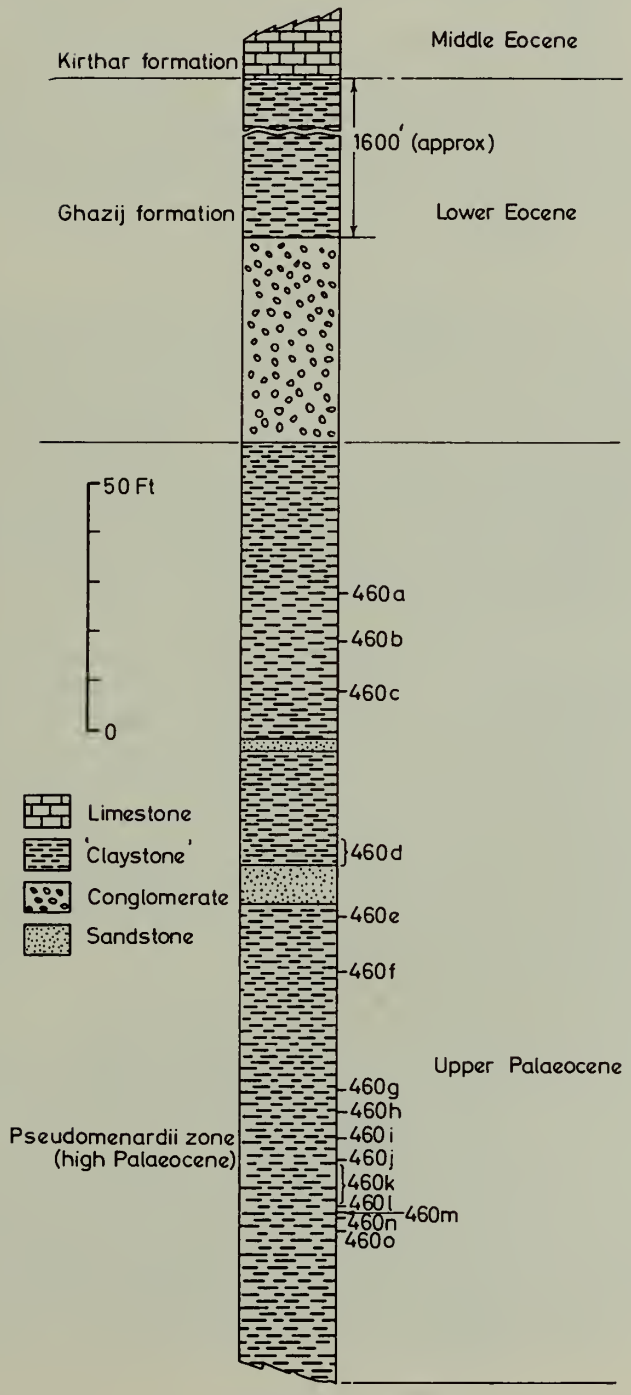


FIG. 6

DIAGNOSIS. Medium size, thick shelled. High and distinct anterior marginal rim with posterior ornamentation. Surface sparsely punctate. Subcentral tubercle prominent and rounded.

HOLOTYPE. Io. 4311, a female carapace (Pl. 1, Figs. 2, 3, 11, 12).

PARATYPES. Io. 4260 + Io. 3100–1.

MATERIAL. 29 specimens from the Rakhi Nala section from 8 horizons (sample nos. 3610, to 3615, 3617, 3618 and 3620). 10 specimens from the Zao River section from two horizons (sample nos. 24150 and 24154). GSP BM 2506–7.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 3611.

DESCRIPTION. Sexual dimorphy moderate, the females are higher and wider than the males. *Carapace* sub-rectangular, medium size and thick shelled. Anterior margin broadly rounded, postero-dorsal margin slightly concave, posterior extremity and postero-ventral margin somewhat rounded. Dorsal and ventral margins almost straight, slightly tapering towards the posterior. In lateral view the dorsal ornamentation over-reaches the dorsal margin. Valves almost equal. In dorsal view the greatest width passes through the sub-central node. *Eye-tubercle* rounded, prominent and situated below and slightly anterior to a well-developed anterior cardinal angle. Anterior marginal rim high. Ventral and posterior marginal rims less high. *Sub-central tubercle* prominent, rounded and distinct. Surface sparsely punctate (punctation is not distinct in some specimens), with an alate ventral ridge which slightly slopes upwards towards the posterior. The postero-dorsal process is a blade-like projecting ridge over-reaching the dorsal margin and extending vertically below for a short distance. A prominent mid-dorsal tubercle with a small tubercle present in front. There is also a small tubercle posterior and at some distance from the sub-central node. About 12 short marginal spines anteriorly, partly concealed in external lateral view by the anterior marginal rim, and 5–6 spines posteriorly. *Radial pore canals* few, simple and straight. *Inner margin* and *line of concrescence* coincide. *Duplicature* moderately wide. *Selvage* well marked lying sub-peripheral in left valve, but at some distance from the outer margin in right valve. There is a fairly well-developed *flange groove* in right valve. *Muscle scars* unknown. *Hinge* holamphidont with the details given below :

Hinge element	Left Valve	Right Valve
Anterior	Socket	Conical projecting tooth
Anteromedian	Subconical tooth having a straight anterior and a convex posterior in dorsal view	Deep socket
Posteromedian	Denticulate bar	Shallow locellate groove
Posterior	Slightly elongate socket, open on venter.	Pessular tooth

Dimensions (mm).

		L	H	W
Io. 4260	Carapace male	0·51	0·29	0·27
Io. 4311	Carapace female (holotype)	0·52	0·32	0·29
Io. 3101	Left valve male	0·51	0·29	—
Io. 3100	Right valve male	0·51	0·29	—

Remarks. This species is tentatively assigned to the genus *Actinocythereis*. It differs from the type species of the genus in having a continuous rather than a broken ventral ridge. In addition, the present species is much smaller, has a pitted surface and fewer radial pore canals.

Genus ***ALOCOPOCYTHERE*** nov.

Derivation of name. Greek *alokos*, = furrow, *opos* = eye ; with reference to the furrow behind the eye-tubercle + *cythere*.

Diagnosis. Trachyleberididae in which the eye-tubercle is confluent with both the elevated marginal rim and a short almost vertical ridge, delimited posteriorly by a deep furrow. Anterior and posterior cardinal angles protruding in left valve, only anterior cardinal angle protruding in right valve. Posterior cardinal angle of right valve over-reached by protruding cardinal angle of left valve. Dorsal margin humped.

Type species. *Alocopocythere transcendens* sp. nov.

Description. Dimorphic, the males are proportionally longer than the females. Carapace sub-rectangular to sub-quadrate in shape. Dorsal margin in lateral view sinuous, dominated by protruding anterior and posterior cardinal angles, with a hump between, ventral margin evenly curved or almost straight. Anterior margin broadly rounded, posterior straight or very slightly concave in postero-dorsal margin (between posterior cardinal angle and posterior extremity) ; posterior extremity rounded, postero-ventral region rounded or straight. Valves almost equal in size. Sub-central tubercle and eye-tubercle more or less distinct. Surface ornamentation either reticulate (with or without superimposed lineations or with superimposed papillae) or papillose. A marginal rim always present, usually upstanding anteriorly, less high along venter and posterior. Anterior and posterior margins ornamented with small spines or denticles. Normal pores simple, widely spaced. Radial pore canals simple, almost straight, often slightly inflated towards the middle, tending to occur in groups of two or three, often apparently crossing one another, about 32–35 anteriorly and 18–20 posteriorly. Inner margin and line of concrescence coincide. Duplicature of moderate width. Selvage well-marked—sub-peripheral in left valve but at some distance from the outer margin in the right valve. Right valve with a deep flange groove on the centre and anterior. Muscle scar pattern consists of four adductors in a vertical row situated on the posterior margin of the muscle scar pit and an oval frontal scar with two more or less rounded mandibular scars below. Hinge holamphidont. Right valve with highly projecting, stirpate anterior tooth,

postjacent socket, posteromedian locellate groove and a pessular posterior tooth ; left valve with anterior socket, anteromedian sub-conical tooth, postero-median denticulate bar and a deep posterior socket.

Comparison. This genus differs from *Echinocythereis* in having a short vertical ridge below and a furrow behind the eye-tubercle, also there are two frontal scars in *Echinocythereis*, but only one in *Alocopocythere*. *Stigmatocythere* has a curved ridge joining the eye-tubercle and the sub-central tubercle, whereas in *Alocopocythere* a short, almost vertical ridge joins the eye-tubercle and is delimited posteriorly by a furrow. *Henryhowella* has three longitudinal plications in the posterior half of the valve and an anterior vestibule, not present in *Alocopocythere*. Moreover, the frontal scar in *Henryhowella* is V-shaped, while *Alocopocythere* has an oval frontal scar.

Remarks. In addition to the species described here, the Miocene species *Trachyleberis fossularis* Lubimova and Guha (1960, p. 40, pl. 3, fig. 7), which Guha in 1961 (p. 4, figs. 5, 9) transferred to the genus *Echinocythereis* should be ascribed to *Alocopocythere*.

Alocopocythere transcendens sp. nov.

(Plate 1, figs. 4, 5, 8, 9 ; Plate 2, figs. 1–4, 6, 7)

Derivation of name. Latin, *transcendens*, rising above ; with reference to the stratigraphic position in relation to *A. abstracta*.

Diagnosis. Strongly reticulate *Alocopocythere* with rounded postero-ventral margin, sub-central tubercle more or less distinct, eye-tubercle distinct, marginal rim well marked.

Holotype. Io. 4315, a female left valve (Pl. 2, figs. 1, 6).

Paratypes. Io. 4261 + Io. 3104–6.

Material. 263 specimens from the Zao River section from 7 horizons (sample nos. 24127, 24131, 24132, 24145, 24147, 24148 and 24151). Approximately 600 specimens from the Rakhi Nala section from 46 horizons (sample nos. 3168, 3198, to 3200, 3401 to 3405, 3407, 3409, 3410, 3418, to 3422, 3424, 3426, 3428, 3429, 3432, 3434, 3435, 3438, 3457 to 3459, 3498, 3499, 3607, 3614, 3615, 3617 and 3618). GSP. BM. 2508.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24148.

Description. *Carapace* sub-rectangular to sub-quadrate in lateral outline. Sexual dimorphism rather marked, the females being shorter, higher and wider than the males. Dorsal margin sinuous with protruding anterior and posterior cardinal angles, ventral margin almost straight in the right valve but evenly curved in the left valve. Anterior margin broadly rounded, postero-dorsal margin very slightly concave particularly in the right valve, posterior extremity rounded, postero-ventral margin rounded. Valves almost equal in size. *Eye-tubercle* distinct, rounded and polished. *Sub-central tubercle* more or less distinct. Shell surface strongly

reticulate. Antero-dorsal furrow deep, bounded anteriorly by a short almost vertical ridge joining the eye-tubercle. Anterior marginal rim high, continuing as a less high rim round the venter and posterior. Anterior margin ornamented with 8–10 short spines, posterior with a postero-ventral spine, although these are preserved in a few specimens only. *Duplicature* moderately wide, 0·073 mm. anteriorly in right valve female. *Selvage* prominent in both valves, situated in the outer third of the duplicature in right valve but sub-peripheral in left valve. Along the venter it is markedly concave antero-medially. Right valve has well-developed ventral and anterior *flange grooves*. *Normal pore canals* simple, small. *Radial pore canals* more or less straight, simple, some in groups of two or three, frequently crossing each other. There are approximately 35 radial pore canals in the anterior and 20 in the posterior. *Line of concrescence* and *inner margin* coincide throughout. *Muscle scars* consist of sub-vertical row of four adductors, situated on the posterior margin of the muscle scar pit, with an oval frontal scar and two somewhat rounded mandibular scars below. *Hinge* holamphidont with the following details :

Element	Left valve	Right valve
Anterior	Deep socket confluent with ocular sinus, bounded on all sides.	Highly projecting stirpate tooth, ocular sinus lies below it.
Anteromedian	Subconical tooth with straight anterior and convex posterior in dorsal outline.	Deep rounded socket opening into postero-median groove
Posteromedian	Denticulate bar	Locellate groove
Posterior	Deep slightly elongate socket open on ventral side.	Pessular tooth, high on posterior tending towards reniform.

Dimensions (mm).

		L	H	W
Io. 3104	Carapace male	0·72	0·43	0·42
Io. 4315	Left valve female (holotype)	0·63	0·44	—
Io. 3105	Right valve female	0·64	0·39	—
Io. 4261	Left valve female	0·59	0·39	—
Io. 3106	Right valve male	0·63	0·38	—

Comparison. *Alocopocythere abstracta* sp. nov. is a very closely related species, but is more elongate, and has a straight rather than rounded posteroventral margin and less deep reticulations. *Alocopocythere transcendens* is perhaps ancestral to *Alocopocythere transversa* sp. nov. but is smaller, and lacks the posterior concentric ridges and a short ridge in the anteroventral area. *Alocopocythere fossularis* (Lubimova and Guha) (1960) from the Miocene of Kutch is a similar species but which differs however, in the lateral outline of the carapace.

Remarks. Specimens of *A. fossularis* (Lubimova and Guha) from the type locality in Kutch were not available for comparison.

Alocopocythere rupina sp. nov.

(Plate 2, figs. 5, 8–10 ; Plate 3, figs. 1–4)

Derivation of name. Latin, *rupina*, " chasm " ; with reference to the anterodorsal furrow and associated ridges.

Diagnosis. *Alocopocythere* in which anterodorsal furrow is delimited anteriorly by a short almost vertical ridge and posteriorly by the anterior part of the dorsal ridge. Surface reticulate with seven longitudinal ridges. Anterior and posterior plains almost smooth.

Holotype. Io. 4314, a male carapace (Pl. 2, figs. 5, 8–10).

Paratype. Io. 4262.

Material. 41 specimens from the locality below from one horizon (sample no. 3111). GSP BM 2509–10.

Type locality. Rakhi Nala section.

Type horizon. Gorge Beds, sample no. 3111.

Description. Sexual dimorphism strong, the males are longer than the females. *Carapace* subrectangular in lateral view. Dorsal margin sinuous, ventral margin slightly concave in front of the middle, anterior margin broadly rounded, posterior narrowly rounded. Anterior cardinal angle protruding particularly in right valve, posterior cardinal angle less well-developed. Left valve slightly over-reaches right valve at anterior cardinal angle and in the region of posterodorsal corner. *Eye-tubercle* rounded and distinct. *Subcentral-tubercle* well-developed. Surface ornamentation with seven longitudinal ridges ; the dorsal ridge begins above and very slightly to the anterior of the subcentral-tubercle and is convex in the middle culminating in the posterior quarter. The four ridges below the dorsal ridge are almost confined posterior to the subcentral-tubercle, the second ridge from the centre is the longest and is slightly curved ; it commences above the anteroventral corner and slopes obliquely upwards towards the posterior ending in the posterior quarter. The ventral ridge is confined in the posterior part of the carapace and is intercalated between the ventral margin and the second ventral ridge, to which it is almost parallel. Anterodorsal furrow well-developed, delimited on the anterior by a short almost vertical ridge, and on the posterior by the anterior portion of the dorsal ridge. Anterior and posterior platforms almost smooth, compressed. Anterior marginal rim elevated, ventral and posterior marginal rims less high. *Radial pore canals* not detectable. *Duplicature* moderate. *Selvage* well-marked ; it is submarginal in left valve but in the outer third of the duplicature in right valve, which also has well-developed anterior and ventral *flange grooves*. *Hinge* holamphidont with stirpate anterior tooth in right valve.

Dimensions (mm).

		L	H	W
Io. 4314	Carapace male (holotype)	0·68	0·37	0·34
Io. 4262	Carapace female	0·59	0·37	0·34

Comparison. *A. rupina* can easily be differentiated from other known species of

Alocopocythere by its anterodorsal groove, which is not only delimited by an anterior ridge but by a posterior ridge as well.

Remarks. This is so far the oldest known species of the genus *Alocopocythere*. It occurs abundantly in one horizon (sample no. 3111) of the Gorge Beds of the Rakhi Nala section, the male to female ratio being 1 : 3.

Alocopocythere abstracta sp. nov.

(Plate 3, figs. 5–11 ; Plate 4, fig. 1)

Derivation of name. Latin *abstractus*, separated, referring to the difficulty in separating this species from *A. transcendens* because of the many intermediate forms.

Diagnosis. A reticulate *Alocopocythere* with straight postero-ventral margin in lateral outline. Subcentral-tubercle present but not prominent.

Holotype. Io. 4312, a female carapace (Pl. 3, figs. 9–11) ; (Pl. 4, fig. 1).

Paratype. Io. 4263.

Material. Over 2600 specimens (including adults and juveniles) from the Rakhi Nala section from 69 horizons (sample nos. 3147, 3152, 3153, 3157 to 3180, 3183, 3184, 3186 to 3191, 3193 to 3194, 3197 to 3200, 3401 to 3405, 3407, 3409, 3410, 3415 to 3424, 3426, 3428, 3429, 3432, 3434, 3435, 3438, 3443 and 3445). 5 specimens from the Zao River section from one horizon (sample no. 24127). GSP BM 2511–2512.

Type locality. Rakhi Nala section.

Type horizon. Upper Rakhi Gaj Shales, sample no. 3163.

Description. *Carapace* subrectangular in side view. Sexual dimorphism rather pronounced ; the males are longer than the females. Dorsal margin sinuous, ventral margin nearly straight. Anterior margin broadly and evenly rounded, postero-dorsal margin very slightly concave ; posterior extremity rounded ; postero-ventral margin straight. Anterior and posterior cardinal angles protruding. Valves more or less equal. *Eye-tubercle* distinct. *Subcentral-tubercle* present but not pronounced. Surface reticulate. Anterodorsal furrow deep, bounded anteriorly by a short almost vertical ridge diagnostic of the genus. Anterior and posterior margins denticulate, although the denticles are only present in a few specimens. Internal details not known.

Dimensions (mm).

		L	H	W
Io. 4263	Carapace male	0·66	0·38	0·34
Io. 4312	Carapace female (holotype)	0·63	0·39	0·35

Comparison. *Alocopocythere coarctata* sp. nov. is smaller than the present species and has a combination of reticulations and weak ridges and a more sinuous dorsal margin. *Alocopocythere radiata* sp. nov., however, is larger, has deeper reticulations and a better developed subcentral-tubercle having posterior radial ridges.

A. abstracta has already been compared with *Alocopocythere transcendens* sp. nov.

Alocopocythere coarctata sp. nov.

(Plate 4, figs. 2–9)

Derivation of name. Latin *coarctatus*, " pressed together " ; with reference to the carapace.

Diagnosis. *Alocopocythere* in which carapace in lateral outline appears to be compressed ; dorsal and ventral margins tapering towards the posterior end, subcentral-tubercle distinct, anterior marginal rim high, surface finely reticulate (with superimposed weak longitudinal ridges).

Holotype. Io. 4313, a female carapace (Pl. 4, figs. 6–9).

Paratype. Io. 4264.

Material. 49 specimens from the below locality from five horizons (sample nos. 3432, 3434, 3435, 3458 and 3459). GSP BM 2513–4.

Type locality. Rakhi Nala section.

Type horizon. Shales with Alabaster, sample no. 3458.

Description. *Carapace* subrectangular to subquadrate in lateral view. Sexual dimorphism strong ; the females are shorter than the males. Anterior margin broadly and evenly rounded, posterodorsal margin straight, particularly in the left valve, posterior extremity rounded, posteroventral margin rounded. Dorsal margin sinuous with a hump between the protruding anterior and posterior cardinal angles, ventral margin slightly concave in the middle. Both dorsal and ventral margins taper towards the posterior. Valves almost equal. Surface finely reticulate with superimposed weak longitudinal ridges. *Subcentral-tubercle* distinct, *eye-tubercle* more or less distinct. Marginal rim present, elevated in the anterior, less elevated round the venter and posterior. Anterodorsal furrow fairly distinct and is bounded anteriorly by a short almost vertical ridge. Anterior and posterior margins denticulate. Internal characters not known.

Dimensions (mm).

		L	H	W
Io. 4264	Carapace male	0·51	0·27	0·27
Io. 4313	Carapace female (holotype)	0·50	0·32	0·29

Comparison. Unlike *A. coarctata*, *Alocopocythere rupina* sp. nov. has better developed longitudinal ridges and coarser reticulation. In addition, these two species differ in lateral outline, particularly the male dimorphs. *Alocopocythere transcendens*, sp. nov. is larger, has a less well-developed hump between the protruding anterior and posterior cardinal angles and lacks longitudinal ridges.

Alocopocythere longilinea sp. nov.

(Plate 4, figs. 10–13 ; Plate 5, figs. 1–3, 6)

Derivation of name. Latin *longi*, longitudinal + *linea*, line.

Diagnosis. A small *Alocopocythere* in which surface ornamentation is reticulate,

the reticulae being arranged in longitudinal lines with weak ridges in between, subcentral-tubercle indistinct, marginal rim low, anterior marginal area compressed.

HOLOTYPE. Io. 4318, a male carapace (Pl. 4, figs. 10–13).

PARATYPE. Io. 4265.

MATERIAL. Nearly 670 specimens (including adults and juveniles) from the Rakhi Nala section from 10 horizons (sample nos. 3438, 3440, 3443 to 3445, 3448, 3450, 3451, 3457 and 3458). One specimen from the Shpalai Khwara section from one horizon (sample no. 24683). GSP BM 2515–6.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Shales with Alabaster, sample no. 3443.

DESCRIPTION. *Carapace* ovate in lateral outline and slightly tapering towards the posterior. Sexual dimorphism marked ; the males are longer in proportion than the females. Anterior margin broadly and obliquely rounded, somewhat compressed, posterior almost straight, posteroventral margin slightly curved. Dorsal margin sinuous, ventral margin evenly curved. Valves nearly equal. *Subcentral-tubercle* indistinct. *Eye-tubercle* low. Surface ornamentation consists of a combination of reticulations and weak ridges. Anterodorsal furrow deep with a short more or less vertical anterior ridge characteristic of the genus. Marginal rim low. Internal characters unknown.

DIMENSIONS (mm).

		L	H	W
Io. 4318	Carapace male (holotype)	0·54	0·32	0·25
Io. 4265	Carapace female	0·46	0·30	0·24

COMPARISON. The present species differs from *Alocopocythere abstracta* sp. nov. and *Alocopocythere transcendens* sp. nov. in being smaller and having weak longitudinal ridges. Moreover, *A. longilinea* has a low marginal rim and an indistinct subcentral-tubercle. *Alocopocythere coarctata* sp. nov. is about the same size but has a high marginal rim, well-developed subcentral-tubercle and more sinuous dorsal margin.

REMARKS. *A. longilinea* occurs in the lower part of the Shales with Alabaster of the Rakhi Nala section and at several horizons it is very abundant. It is very rare in the Shpalai Khwara section.

Alocopocythere transversa sp. nov.

(Plate 5, figs. 4, 5, 7–10 ; Plates 6–8 ; Plate 9, figs. 1–5)

DERIVATION OF NAME. Latin *transversus*, transverse ; with reference to the posterior ridges.

DIAGNOSIS. A species of the genus *Alocopocythere* with three posterior transverse concentric ridges. A short ridge in the anteroventral area runs obliquely from the anterior towards the venter, a shallow groove on the dorsal side of the ridge. Surface reticulate (with or without superimposed papillae) or papillose.

HOLOTYPE. Io. 4316, a female carapace (Pl. 5, figs. 8, 10) ; (Pl. 6, figs. 1, 2).

PARATYPES. Io. 4266–9 + Io. 3107–12.

MATERIAL. Over 800 specimens from the Zao River section from 20 horizons (sample nos. 24131, 24155, 24157, 24159, 24170, 24173 to 24178, 24180, 24181, 24183 to 24188 and 24195). Approximately 300 specimens from the Rakhi Nala section from 20 horizons (sample nos. 3624 to 3626, 3630, 3631, 3634, 3640 to 3642, 3645, 3646, 3648 to 3653, 3658 and 3660). GSP BM 2157–8.

TYPE LOCALITY. Zao River section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 24155.

DESCRIPTION. Sexual dimorphism rather marked, the males are more elongate than the females. *Carapace* subrectangular in lateral view. Dorsal margin sinuous, ventral margin straight or evenly curved. Anterior margin broadly rounded, posterodorsal margin very slightly concave, posterior extremity rounded, posteroventral margin rounded or almost straight. Anterior and posterior cardinal angles well-developed and protruding. Valves nearly equal. *Eye-tubercle* distinct, polished and rounded. *Subcentral-tubercle* distinct. Surface either reticulate (with or without superimposed papillae) or papillose. There are three posterior transverse concentric ridges approximately parallel to the posterior margin with grooves in between. There is a short ridge in the anteroventral area running obliquely from the anterior towards the venter, with a groove on the dorsal side. Anterodorsal groove fairly deep and bounded on the anterior by a short almost vertical ridge running from the eye-tubercle. The marginal rim is high in the anterior but less high on the venter and posterior. Anterior and posterior margins ornamented with short spines, only present in some specimens and approximately 20 anteriorly and 10 posteriorly. *Normal pore canals* simple, small and numerous. *Radial pore canals* numerous, simple, nearly straight, some in groups of two or three, often apparently crossing one another. *Duplicature* moderately wide. *Selvage* pronounced in the outer third of the duplicature in the right valve but sub-marginal in the left valve. Right valve with deep ventral and anterior *flange grooves*. *Line of concrescence* and *inner margin* coincide. *Muscle scars* consist of four adductors in a vertical row with an oval frontal scar and two almost rounded mandibular scars below. *Hinge* holamphidont :

Element	Left valve	Right valve
Anterior	Deep rounded socket bounded on all sides, confluent with ocular sinus.	Strongly projecting stirpate tooth (ocular sinus situated below and slightly anterior to it).
Anteromedian	Subconical projecting tooth with a straight anterior and convex posterior in dorsal view.	Deep socket.
Posteromedian	Denticulate bar	Locellate groove
Posterior	Deep elongate socket unbounded on venter	Pessular tooth with a tendency towards reniform, higher on posterior.

Comparison. *Alocopocythere radiata* sp. nov. is similar and perhaps related but lacks the posterior concentric ridges. Moreover, *A. radiata* has ventral inflation culminating in a ventral ridge and the longitudinal ridges radiate from the posterior of a subcentral-tubercle.

The present species has already been compared with *Alocopocythere transcendens* sp. nov.

Remarks. This species may be divided into the following morphotypes, which may represent the chronological subspecies of *A. transversa*. However, because of the difficulty in separating these from one another and also owing to the fact that the reticulate forms recur in the Upper Eocene succession of the Rakhi Nala and Zao River sections, these are here considered as morphotypes.

Morphotype A

(Pl. 5, figs. 4, 5, 7–10 ; Pl. 6, figs. 1–4)

This has a reticulate surface. The reticulae are usually without any superimposed papillae but in some specimens a few small papillae at the junction of reticulae are present. The posteroventral margin in lateral outline is curved in the male but straight in the female.

Dimensions (mm).

		L	H	W
Io. 4266	Carapace male	0·76	0·44	0·44
Io. 4316	Carapace female (holotype)	0·71	0·45	0·44
Io. 3107	Right valve male	0·85	0·46	—

Morphotype B

This comprises the transitional forms which fall between Morphotype A and Morphotype C. It has slightly papillose reticulae. Specimens Io. 5004–5 from sample 24155.

Morphotype C

(Plate 6, figs. 5–8 ; Plate 7, figs. 1–4 ; Plate 8, fig. 4)

This is similar to Morphotype B, but has a combination of reticulations and papillae and a curved posteroventral margin in both male and female.

Dimensions (mm).

		L	H	W
Io. 4267	Carapace male	0·78	0·46	0·44
Io. 4268	Carapace female	0·76	0·46	0·44
Io. 4269	Right valve male (broken)	0·80	—	—

Morphotype D

This includes the intermediate forms between Morphotype C and Morphotype E. Specimens Io. 5006–7 from sample 24175.

Morphotype E

(Plate 7, figs. 5–8 ; Plate 8, figs. 1–3, 5)

This is similar in all characters to Morphotype A and Morphotype C but has a papillose surface. It has a curved posteroventral margin in the male and female dimorphs as in Morphotype C. There is a smooth, shallow groove on the dorsal side of the ventral ridge.

Dimensions (mm).

		L	H	W
Io. 3110	Carapace male	0·80	0·46	0·46
Io. 3111	Carapace female	0·74	0·46	0·45

Morphotype F

(Plate 8, figs. 6–9 ; Plate 9, figs. 1–5)

This has a small carapace. The surface is ornamented with slightly papillose reticulae. There is a rim behind the anterior marginal rim and almost parallel to it with reticulations in between. It originates from the eye-tubercle and fuses ventrally with a short, oblique ventral ridge. It is likely that these forms may be juveniles of Morphotype A or Morphotype C or may even belong to a distinct species.

Dimensions (mm).

		L	H	W
Io. 3109	Carapace male	0·68	0·39	0·39
Io. 3108	Carapace female	0·64	0·39	0·38
Io. 3112	Right valve female	0·59	0·37	—

Alocopocythere radiata sp. nov.

(Plate 9, figs. 6–9 ; Plate 10, figs. 1–4)

Derivation of name. Latin *radiatus*, rayed ; with reference to the ridges radiating from the subcentral-tubercle.

Diagnosis. A coarsely reticulate *Alocopocythere* with longitudinal ridges radiating from the posterior of a well-developed subcentral-tubercle. Eye-tubercle distinct, marginal rim high, ventral inflation ends in a marked ridge, almost parallel to the ventral marginal rim.

Holotype. Io. 4317, a male carapace (Plate 9, figs. 6, 8 ; Plate 10, figs. 1, 2)

Paratype. Io. 4270.

Material. 14 specimens from the locality below from one horizon (sample no. 3652). 8 specimens from the Zao River section from one horizon (sample no. 24173). GSP BM 2519–20.

Type locality. Rakhi Nala section.

Type horizon. Upper Chocolate Clays, sample no. 3652.

Description. Sexual dimorphism distinct ; the females are shorter than the

males. *Carapace* subrectangular in lateral view. Dorsal margin sinuous with protruding anterior and posterior cardinal angles ; ventral margin almost straight. Anterior margin broadly and evenly rounded, posterior extremity rounded, posterodorsal margin very slightly concave, posteroventral margin curved in the male dimorph but almost straight in the female. Valves more or less equal. *Eye-tubercle* rounded and distinct. Surface ornamentation consists of coarse reticulations with superimposed ridges radiating from the posterior of a well-developed subcentral-tubercle. The ventral inflation culminates in a marked ventral ridge almost parallel to the ventral marginal rim. There are two ridges which join the eye-tubercle, one a short more or less vertical ridge bounded posteriorly by a deep anterodorsal furrow which is better seen in dorsal view, and the other a high anterior marginal rim which continues along the venter and around the posterior as a less high rim. Anterior and posterior margins decorated with numerous very short and delicate spines.

Dimensions (mm).

		L	H	W
Io. 4317	Carapace male (holotype)	0·72	0·42	0·42
Io. 4270	Carapace female	0·68	0·42	0·40

Comparison. *Alocopocythere transcendens* sp. nov. shows some resemblance and is perhaps ancestral to the present species ; but *A. transcendens* has a less well-developed subcentral-tubercle without radial ridges and lacks a ventral inflation ending in a ridge. *Alocopocythere coarctata* sp. nov. is much smaller, has a carapace which tapers towards the posterior end and has a less deep surface reticulation.

Genus *" ANOMMATOCYTHERE "* Sohn

Type species. *" Anommatocythere microreticulata "* Sohn.

Remarks. This is a new genus erected by Sohn whose paper is in press. The two species described below are provisionally assigned to the genus but their final designation will depend on the publication of Sohn's paper.

" Anommatocythere " laqueata sp. nov.

(Plate 10, figs. 5–10)

Derivation of name. Latin *laqueatus*, fluted ; with reference to the ornamentation of the anterior rim.

Diagnosis. Anterior rim ornamented with seven small more or less rectangular depressions. Carapace subtriangular with a gently convex dorsal margin.

Holotype. Io. 4320, a female carapace (Plate 10, figs. 8–10).

Paratype. Io. 4271.

Material. 32 specimens from the locality below from three horizons (sample nos. 3403, 3405 and 3466). Two specimens from the Zao River section from one horizon (sample no. 24107). GSP BM 2521–2.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Green and Nodular Shales, sample no. 3403.

DESCRIPTION. Sexual dimorphy rather apparent ; the males are longer in proportion than the females. *Carapace* subtriangular in lateral view. Dorsal margin gently convex, ventral margin almost straight, anterior margin broadly rounded, posterior with a caudal process. Greatest length lies below mid-point, greatest height at anterior cardinal angle. Anterior and posterior cardinal angles more or less rounded, somewhat better developed in the left valve. Left valve very slightly larger than the right valve, over-reaching it in the anterodorsal corner and posterodorsal slope. *Subcentral-tubercle* indistinct. *Eye-tubercle* distinct but low. Surface reticulate, the reticulae being arranged in lines separated by longitudinal ribs. Anterior marginal rim ornamented with seven small rectangular depressions like a scallop or bivalve mollusc. Internal characters not observed.

DIMENSIONS (mm).

		L	H	W
Io. 4271	Carapace male	0·66	0·37	0·32
Io. 4320	Carapace female (holotype)	0·66	0·39	0·34

COMPARISON. "*Anommatocythere*" *confirmata* sp. nov. differs from the present species by having a thick-shelled and ventrally inflated carapace, a convex rather than straight ventral margin in lateral view, and no ornamentation of the anterior rim.

REMARKS. Specimens from the Shales with Alabaster show fainter longitudinal ribs. This is perhaps due to the form of preservation.

"*Anommatocythere*" *confirmata* sp. nov.

(Plate 10, figs. 11, 12 ; Plate 11 ; Plate 12, figs. 1, 2)

DERIVATION OF NAME. Latin *confirmatus*, "strengthened" ; with reference to the variation in the strength of the longitudinal ribs.

DIAGNOSIS. Carapace ventrally inflated and with a short caudal process. Ventral longitudinal ribs are curved and better developed. Anterior and posterior cardinal angles well-marked.

HOLOTYPE. Io. 4319, a male carapace (Pl. 10, figs. 11, 12) ; (Pl. 11, figs. 1, 2)

PARATYPE. Io. 4272 + Io. 3102–3.

MATERIAL. 70 specimens from the Rakhi Nala section from five horizons (sample nos. 3499, 3611, 3613–3615). 53 specimens from the Zao River section from six horizons (sample nos. 24145, 24147, 24148, 24150 to 24152). GSP BM 2523–4.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 3611.

DESCRIPTION. Sexual dimorphism rather marked, the females are shorter and wider in proportion than the males. *Carapace* plump, thick-shelled and with ventral inflation. Dorsal margin slightly convex particularly in the right valve, ventral

margin anteromedially concave but is convex in lateral outline due to the ventral inflation ; anterior margin broadly rounded, posterior with a short caudal process. Anterior and posterior cardinal angles well-developed particularly in the left valve. Left valve slightly over-reaches the right at the anterodorsal and posterodorsal corners. *Subcentral-tubercle* present but not distinct. *Eye-tubercle* rounded, shiny and distinct and lies below and slightly anterior to cardinal angle. Surface ornamentation consists of reticulations and longitudinal ribs. There is a variation in the strength of the longitudinal ribs, those on the ventral surface are stronger and curved convexly downwards in the middle. Marginal rim narrow and low. Anterior and posterior margins denticulate. Valves deep in internal view. *Normal pore canals* fairly numerous and perhaps each reticule has one normal pore canal. *Radial pore canals* simple, straight, sparse, irregularly spaced, few crossing one another, approximately 20 anteriorly and 8 posteriorly. *Line of concrescence* and *inner margin* coincide—no *vestibule*. *Duplicature* fairly wide—0·073 mm. anteriorly, 0·055 mm. on the posterior extremity. *Selvage* distinct and subperipheral ; situated in the right valve on the outer sixth of the anterior margin. Right valve with a ventral *flange groove* between selvage and flange. *Muscle scar* pattern with four adductor scars in an almost vertical superposition at the posterior margin of the muscle scar pit and two more or less rounded frontal scars. *Hinge* holamphidont with the following details of the hinge elements :

Element	Left valve	Right valve
Anterior	Deep socket bounded on all sides, eye-socket lies almost in the middle of it.	Strongly projecting stirpate tooth.
Anteromedian	Conical tooth, projecting slightly towards anterior.	Deep socket narrowing posteriorly into a long groove.
Posteromedian	Denticulate bar	Locellate groove, the anterior part deeper than posterior.
Posterior	Deep and elongate socket unbounded on ventral side.	Large bilobate tooth, the anterior lobe lower than the posterior.

Dimensions (mm).

		L	H	W
Io. 4319	Carapace male (holotype)	0·66	0·39	0·39
Io. 4272	Carapace female	0·63	0·42	0·44
Io. 3102	Left valve male	0·64	0·39	—
Io. 3103	Right valve male	0·63	0·37	—

Comparison. This species has already been compared with " *Anommatocythere* " *laqueata* sp. nov.

Remarks. The vertical range of the present species in the Rakhi Nala and Zao

River sections is 286 ft. and 378 ft. respectively. Hence, it is a very useful species as a horizon marker in the region.

Adult specimens in the two sections vary in size and in the strength of ornamentation.

Genus *BRADLEYA* Hornibrook 1952

TYPE SPECIES. *Cythere arata* Brady 1880.

Bradleya ? voraginosa sp. nov.

(Plate 12, figs. 3–9)

DERIVATION OF NAME. Latin *voraginosus*, full of pits.

DIAGNOSIS. A species provisionally placed in the genus *Bradleya* with subparallel dorsal and ventral margins, projecting anterior cardinal angle, truncated posterior, coarsely and deeply reticulate surface.

HOLOTYPE. Io. 4321, a male carapace (Pl. 12, figs. 3, 5, 7, 8).

PARATYPE. Io. 3115.

MATERIAL. 10 specimens from the locality below from two horizons (sample nos. 24159 and 24161). GSP BM 2525.

TYPE LOCALITY. Zao River section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 24161.

DESCRIPTION. *Carapace* subrectangular in lateral outline. Valves ventrally inflated. Dorsal and ventral margins almost straight and subparallel, anterior margin broadly rounded, posterior truncated, posterodorsal slope very slightly concave particularly in the right valve. Anterior cardinal angle projecting, posterior cardinal angle rather prominent (approximately 110°). Valves almost equal. *Eye-tubercle* rounded and distinct and situated just below the anterior cardinal angle. *Subcentral-tubercle* more or less distinct. A marginal rim runs around the anterior, ventral and posterior margins. It is fairly well-developed anteriorly and posteriorly but is not so prominent along the venter. Surface ornamentation consists of coarse, deep reticulations and dorsal and ventral ridges.

The dorsal ridge is ill-defined in the anterior half, slightly arched upward in the posterior third culminating in a short horn-like posterodorsal process. The ventral ridge is better developed and slightly alate posteriorly. Anterior margin finely denticulate, posteroventral margin ornamented with 4–5 short spines. Internal details not very well displayed. *Duplicature* fairly wide. *Selvage* in the left valve is subperipheral and less well-developed than in the right valve where it is at some distance from the outer margin. It has a deep *flange groove*, particularly in the venter. *Hinge* holamphidont ; left valve with a deep almost rounded anterior socket which is bounded on all sides, a conical projecting anteromedian tooth, an apparently denticulate bar and a deep elongate posterior socket which is bounded on the venter. Hinge of right valve not clearly seen.

DIMENSIONS (mm).

		L	H	W
Io. 4321	Carapace male (holotype)	0·76	0·42	0·42
Io. 3115	Carapace female	0·73	0·40	0·42

COMPARISON. *Bradleya ? cornuelina* (Bosquet) Keij (1957) is similar to *B ? voraginosa* in lateral view but has three rather than two longitudinal ridges. Further, it has a less well-developed anterior cardinal angle. *Bradleya approximata* (Bosquet) Keij (1957) has a different posterior and larger posteroventral spines.

Genus ***BUNTONIA*** Howe 1935

TYPE SPECIES. *Buntonia shubutaensis* Howe 1935.

Buntonia devexa sp. nov.

(Plate 13, figs. 1–5)

DERIVATION OF NAME. Latin *devexus*, sloping ; with reference to the tapering lateral outline.

DIAGNOSIS. A species of *Buntonia* in which carapace is elongate, subrectangular in lateral view ; surface ornamented with 9–11 longitudinal ribs in posterior three-fifths of carapace.

HOLOTYPE. Io. 4322, a female carapace (Pl. 13, figs. 2, 4, 5).

PARATYPE. Io. 3113.

MATERIAL. 8 specimens from the locality and horizon below.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Gorge Beds, sample no. 3111.

DESCRIPTION. Sexual dimorphism rather pronounced ; the males are longer and less wide than the females. *Carapace* sub-triangular in lateral view, tapering towards the posterior. Anterior margin broadly and obliquely rounded, posterior narrowly rounded, dorsal and ventral margins almost straight, dorsal margin slopes downwards towards posterior. Greatest length passes through the midpoint, greatest height in the anterior third and greatest width in the posterior two-fifths. Anterior cardinal angle rounded. Left valve slightly larger than the right valve. Surface ornamentation consists of 9–11 longitudinal ridges, which are more or less confined in the posterior three-fifths. Anterior marginal rim distinct.

DIMENSIONS (mm).

		L	H	W
Io. 3113	Carapace male	0·80	0·39	0·24
Io. 4322	Carapace female (holotype)	0·73	0·35	0·27

COMPARISON. *Buntonia virgulata* Apostolescu (1961) has punctae between longitudinal ridges and a less elongate carapace. *Cythere* cf. *costellata* (Roemer) Latham (1938) is similar and may even be conspecific. However, her figure, which

appears to be drawn upside down, shows longitudinal ridges continuing in the anterior part of the carapace.

Remarks. *Cythere costellata* (Roemer) is now regarded as a species of the genus *Cytheretta*. Because of the imperfect preservation, it has not been possible to observe whether the present species has any eye-tubercles.

Buntonia Sp.A

(Plate 13, figs. 6, 7, 9)

Figured specimen. Io. 3114.

Material. Two specimens from the locality and horizon below.

Locality. Rakhi Nala section.

Horizon. Lower Rakhi Gaj Shales, sample no. 3133.

Description. *Carapace* small, almost triangular in lateral outline. Greatest length lies below mid-point, greatest height in anterior third. In dorsal view the carapace is widest just posterior to the middle and tapers towards anterior and posterior ends ; posterior pointed. Anterior end broadly and obliquely rounded, posterior narrow and somewhat rounded ; dorsal and ventral margins taper towards the posterior. Anterior cardinal angle rounded and well-developed. Left valve larger than right valve. Surface ornamented with some ten longitudinal ridges.

Dimensions (mm).

		L	H	W
Io. 3114	Carapace	0·50	0·27	0·32

Comparison. *Buntonia devexa* sp. nov. (Pl 13, figs. 1–5) is much larger, has a less triangular carapace with a gentle slope on the dorsal margin. Further, *B. devexa* has a rounded rather than pointed posterior in dorsal view and has longitudinal ridges which do not continue towards the anterior.

Genus ***COSTA*** Neviani 1928

Diagnosis. Trachyleberididae in which ornamentation is dominated by three or four longitudinal ridges, the median or second ridge running back from the sub-central-tubercle towards posterodorsal corner in anterior two-thirds of length, then curving sharply down towards posteroventral corner in posterior third of length.

Type species. *Cytherina edwardsii* Roemer 1838.

Subgenus ***COSTA*** sensu stricto

Diagnosis. *Costa* with three longitudinal ridges.

Subgenus ***PARACOSTA*** nov.

Derivation of name. Greek *para*, near ; with reference to the strong resemblance to the subgenus *Costa*.

Diagnosis. *Costa* with a fourth ventral ridge intercalated between third ridge and ventral margin.

Type species. *Costa* (*Paracosta*) *declivis* sp. nov.

Remarks. The subgenus *Paracosta* is so far only known from the Rakhi Nala section. It is represented by two species in the Upper Chocolate Clays and one species in the Pellatispira Beds.

Costa (Paracosta) declivis sp. nov.

(Plate 13, figs. 8, 10–14 ; Plate 14, figs. 1, 2)

Derivation of name. Latin *declivis*, sloping downward ; referring to the direction of the ridge running anteroventrally from the subcentral-tubercle.

Diagnosis. A small species of *Paracosta* in which longitudinal ridges are well-developed, median or second ridge runs anteroventrally from subcentral-tubercle.

Holotype. Io. 4325, a male carapace (pl. 13, figs. 8, 10–12).

Paratypes. Io. 4273—Io. 3116.

Material. 34 specimens from the Rakhi Nala section from four horizons (sample nos. 3661 to 3664). GSP BM 2526–7.

Type locality. Rakhi Nala section.

Type horizon. Pellatispira Beds, sample no. 3662.

Description. Sexual dimorphism marked, the males are longer than the females. *Carapace* elongate, subrectangular in lateral view with greatest height at anterior cardinal angle. Dorsal and ventral margins almost straight, subparallel, anterior end broadly rounded, posterior subtriangular. Valves almost equal. Anterior cardinal angle rounded, posterior cardinal angle obtuse. Greatest width in the posterior third. *Subcentral-tubercle* distinct. *Eye-tubercle* rounded and distinct. Ornamentation consists of reticulations dominated by four longitudinal ridges. The dorsal ridge commences just above the subcentral-tubercle and is slightly arched upward (in lateral view over-reaching dorsal margin), the median or second ridge runs almost diagonally from anteroventral margin towards posterodorsal corner, then bending down towards posteroventral margin ; the ventral or fourth ridge (better seen in ventral view) lies between the third ridge and the ventral margin and is not as well-developed as the other three. Anterior and posterior marginal rims high. Anterior margin ornamented with 15–18 small spines, posteroventral margin with 5–6 relatively large spines. Internal characters unknown.

Dimensions (mm).

		L	H	W
Io. 4325	Carapace male (holotype)	0·83	0·39	0·37
Io. 4273	Carapace female	0·77	0·39	0·37
Io. 3116	Carapace female	0·77	0·39	0·37

Comparison. This species differs from *Costa* (*Paracosta*) *disintegrata* sp. nov. in having well-developed longitudinal ridges and a different outline. *Costa* (*Paracosta*)

compitalis sp. nov. is larger, lacks well-developed longitudinal ridges and has a ridge running from the eye-tubercle to the subcentral-tubercle.

Costa (Paracosta) compitalis sp. nov.

(Plate 14, figs. 3–10)

Derivation of name. Latin *compitalis*, pertaining to a cross-roads ; referring to the nexus of the ridges running from the subcentral-tubercle.

Diagnosis. A large, strongly reticulate species of the subgenus *Paracosta* in which longitudinal ridges are moderately developed, subcentral-tubercle prominent, joined by three ridges—dorsal, median and a ridge running from eye-tubercle.

Holotype. Io. 4323, a female carapace (Pl. 14, figs. 5, 6, 9, 10).

Paratype. Io. 4274.

Material. 14 specimens from the locality below from one horizon (sample no. 3604). GSP BM 2528–9.

Type locality. Rakhi Nala section.

Type Horizon. Upper Chocolate Clays, sample no. 3604.

Description. *Carapace* subrectangular in lateral outline. Sexual dimorphism rather pronounced ; the females are shorter and higher than the males. Dorsal margin slightly curved in lateral view because of over-reaching by the dorsal ridge ; ventral margin straight, anterior broadly and evenly rounded, posterodorsal margin very slightly concave, posterior extremity slightly subtriangular, posteroventral margin rounded. Greatest height at anterior cardinal angle, greatest length through the mid-point and greatest width in posterior third. Anterior cardinal angle well-developed with a concavity behind. Left valve slightly larger than right valve, over-reaching at posterodorsal margin and in the region of anterior cardinal angle. *Eye-tubercle* rounded and distinct and confluent with the anterior marginal rim and a ridge running from the subcentral-tubercle. The prominent *subcentral-tubercle* lies more or less in the anterior third. Surface coarsely reticulate. There are four longitudinal ridges ; the dorsal ridge commences at the subcentral-tubercle and is curved convexly upward, the median or second ridge stretches back from the subcentral-tubercle towards posteroventral margin, the third ridge slightly slopes upward towards the posterior end and the ventral ridge is almost parallel to the ventral margin and is intercalated between the third ridge and the ventral margin. Anterior and posterior marginal rims distinct. Anterior and posterior margins ornamented with numerous small spines. Internal details not known.

Dimensions (mm).

		L	H	W
Io. 4274	Carapace male	0·98	0·51	0·46
Io. 4323	Carapace female (holotype)	0·93	0·51	0·44

Comparison. *Costa* (*Paracosta*) *disintegrata* sp. nov. is smaller than the present species, has ill-defined longitudinal ridges and a carapace tapering towards the posterior end.

Costa (Paracosta) disintegrata sp. nov.

(Plate 14, figs. 11 ; Plate 15, figs. 1–6)

Derivation of name. Latin *disintegratus*, " broken down " ; referring to the relict nature of the ridges characteristic of *Costa*.

Diagnosis. *Paracosta* of medium size with weakly developed longitudinal ridges. Carapace tapering towards posterior end in lateral view.

Holotype. Io. 4324, a male carapace (Pl. 14, figs. 11 ; Pl. 15, figs. 3, 4).

Paratype. Io. 4275.

Material. Four specimens from the locality below from two horizons (samples no. 3621 and 3622). GSP BM 2530–31.

Type locality. Rakhi Nala section.

Type horizon. Upper Chocolate Clays, sample no. 3622.

Description. Sexual dimorphy moderate ; the males are longer in proportion than females. *Carapace* subrectangular, tapering to posterior in side view. Dorsal and ventral margins almost straight, anterior margin broadly and evenly rounded, posterior subtriangular. Anterior cardinal angle rounded, posterior cardinal angle obtuse—well-developed in left valve. Left valve over-reaches the right slightly at the anterior cardinal angle and in the region of the posterodorsal slope. A distinct *eye-tubercle* lies just below the anterior cardinal angle. *Subcentral-tubercle* well-developed. Anterior and posterior marginal rims high. Surface coarsely reticulate (some reticulae being slightly papillose). There are four ill-defined longitudinal ridges ; the dorsal ridge commences just behind the subcentral tubercle and is curved convexly upward ; the second ridge stretching back from the subcentral-tubercle towards the posterodorsal corner in the anterior two-thirds and then bends sharply round towards the posteroventral corner ; the third ridge commences below the subcentral-tubercle and slopes upward towards the posterior end ; the fourth ridge (better seen in ventral view) is more or less parallel to the third ridge and lies between the ventral margin and the third ridge. Anterior and posterior margins spinose.

Dimensions (mm).

		L	H	W
Io. 4275	Carapace male	0·83	0·42	0·32
Io. 4324	Carapace female (holotype)	0·85	0·44	0·37

Comparison. This species falls between *Costa* (*Paracosta*) *compitalis* sp. nov. and *Costa* (*Paracosta*) *declivis* sp. nov. in size and stratigraphical position and has already been compared with these species.

Genus *ECHINOCYTHEREIS* Puri 1954

Diagnosis. Trachyleberididae with or without ventral ridges. Carapace often inflated and with curved posteroventral margin, particularly in right valve. Surface ornamented with papillae, nodes, reticulations (or combination of these—con-

centrically arranged in some species) or almost smooth. Muscle scars are in a vertical column of four adductors with two frontal scars.

TYPE SPECIES. *Cythereis garetti* Howe and McGuirt 1935.

Subgenus ***ECHINOCYTHEREIS*** sensu stricto

DIAGNOSIS. *Echinocythereis* without ventral ridges.

Echinocythereis (Echinocythereis) contexta sp. nov.

(Plate 15, figs. 7, 8, 10, 13)

DERIVATION OF NAME. Latin *contextus*, joined together ; from the ornamentation of the papillae joined by the walls of the reticulae.

DIAGNOSIS. A species of the subgenus *Echinocythereis* in which posterior end is obliquely rounded towards posterodorsal corner, eye-tubercle prominent, surface reticulate with superimposed papillae.

HOLOTYPE. Io. 4326, a female carapace (Pl. 15, figs. 8, 13).

PARATYPE. Io. 4276.

MATERIAL. Five specimens from the Sor Range section from four horizons (sample nos. 460-f, 460-i, 460-j and 460-o). GSP BM 2532–3.

TYPE LOCALITY. Sor Range section.

TYPE HORIZON. Upper Palaeocene, sample no. 460-i.

DESCRIPTION. Sexual dimorphism rather strong ; the *carapace* is subrectangular in the male and subquadrate in the female. Dorsal margin in lateral outline undulating because of ornamentation, ventral margin almost straight, anterior broadly and evenly rounded. Greatest length passes above the mid-point, greatest height in the anterior fourth and greatest width behind the middle. Anterior and posterior cardinal angles well-developed. Left valve larger than the right, over-reaching it at the anterior, ventral and posterodorsal margins. *Eye-tubercle* rounded and prominent, standing out from the shell surface in lateral and dorsal views. *Subcentral-tubercle* more or less distinct. Surface ornamentation consists of slightly papillose reticulae which are concentrically arranged near the margins. Anterior and posterior margins are set with a double row of papillae ; those on the posterior are larger, and in some specimens become short spines. Internal details not seen.

DIMENSIONS (mm).

		L	H	W
Io. 4276	Carapace male	0·78	0·44	0·37
Io. 4326	Carapace female (holotype)	0·71	0·46	0·42

COMPARISON. Unlike *E.* (*E.*) *contexta* sp. nov. *Echinocythereis* (*Scelidocythereis*) sp.A has a straight rather than curved posterodorsal margin and less prominent eye-tubercles. Moreover, it has a weak ventral ridge and a short horn-like posterodorsal process. *Echinocythereis* (*Echinocythereis*) *elongata* sp. nov. also differs by possessing a very elongate carapace and a better developed subcentral-tubercle.

Echinocythereis (Echinocythereis) elongata sp. nov.

(Plate 15, figs. 9, 11, 12, 14 ; Plate 16, figs. 1, 2)

Derivation of name. Latin *elongatus*, elongate ; with reference to the carapace.

Diagnosis. An elongate species of the subgenus *Echinocythereis* in which posterior end is rounded towards posterodorsal corner, subcentral-tubercle distinct, surface ornamented with reticulae and papillae.

Holotype. Io. 4327, a female carapace (Pl. 15, figs. 12, 14 ; Pl. 16. fig. 1).

Paratype. Io. 3130.

Material. Nine specimens from the Rakhi Nala section from three horizons (sample nos. 3404, 3409 and 3416). GSP BM 2534.

Type locality. Rakhi Nala section.

Type horizon. Rubbly Limestones, sample no. 3416.

Description. *Carapace* elongate, subrectangular in lateral outline. Sexual dimorphism rather prominent in dorsal view ; males longer and less wide than females. Anterior margin broadly rounded, posterior narrowly rounded towards posterodorsal corner particularly in the left valve, dorsal margin irregular due to ornamentation, ventral margin more or less straight. Greatest length lies above the middle, greatest height at the anterior cardinal angle and greatest width in front of the middle. Valves almost equal. *Subcentral-tubercle* distinct. *Eye-tubercle* fairly distinct, but worn in some specimens. Surface ornamentation a combination of reticulations and papillae. The reticulae are in the anterior and ventral regions and the papillae in the middle and posterior. The papillae are perhaps revealed by the removal of an upper layer of reticulae. The decorated papillae show normal pore canals and nexus of reticulae, which are smaller than the anterior and ventral ones. *Normal pore canals* are situated between the papillae. Anterior and posterior margins denticulate, although the denticles are not preserved in some specimens. Internal characters unknown.

Dimensions (mm).

		L	H	W
Io. 3130	Carapace male	0·73	0·39	0·29
Io. 4327	Carapace female (holotype)	0·71	0·38	0·34

Comparison. This species can easily be separated from the other known species of the subgenus *Echinocythereis* by its much more elongate carapace.

Subgenus ***SCELIDOCYTHEREIS*** nov.

Derivation of name. Greek *skelis*, rib ; with reference to the development of the ventral ridges.

Diagnosis. *Echinocythereis* with ventral ridges.

TYPE SPECIES. *Echinocythereis* (*Scelidocythereis*) *multibullata*. sp. nov.

Echinocythereis (Scelidocythereis) multibullata sp. nov.

(Plate 16, figs. 3–9 ; Plate 17, figs. 1, 2, 7)

DERIVATION OF NAME. Latin *multus*, much + *bullatus*, knobbed ; with reference to the ornamentation.

DIAGNOSIS. A species of the subgenus *Scelidocythereis* with a prominent subcentral-tubercle consisting of 4–5 small nodes. Surface nodose or tuberculate. Right valve over-reaches left valve anteriorly but is over-reached by the latter at anterior and posterior cardinal angles.

HOLOTYPE. Io. 4328, a male carapace (Pl. 16, figs. 3, 5, 6 ; Pl. 17, fig. 7).

PARATYPES. GSP BM 2558–Io. 3133–4 + Io. 4277.

MATERIAL. 76 specimens from the Zao River section from five horizons (sample nos. 24154, 24156, 24159, 21461 and 24183). 28 specimens from the Rakhi Nala section from three horizons (sample nos. 3621, 2624 and 2625). GSP BM 2535–6.

TYPE LOCALITY. Zao River section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 24161.

DESCRIPTION. Sexual dimorphism rather marked ; presumed females shorter, higher and wider than presumed males. *Carapace* subrectangular in lateral view. Anterior margin broadly and evenly rounded in both valves. In the right valve the posterodorsal corner is very slightly concave, whilst the posterior extremity and the posteroventral margins are rounded ; in the left valve the posterior end is truncated. Dorsal margin intricate in lateral view because of ornamentation ; ventral margin slightly incurved anterior to the middle in the right valve but curved convexly downward in the left valve. Greatest length passes through the middle, greatest height at the anterior cardinal angle and greatest width in front of the middle (i.e. at the subcentral-tubercle). Anterior cardinal angle protruding. Right valve over-reaches the left at the anterior margin and posteroventral margin ; but left valve over-reaches the right in the region of the anterior and posterior cardinal angle. *Subcentral-tubercle* prominent and is composed of 4–5 small nodes. *Eye-tubercle* rounded and distinct. Surface ornamented with nodes, or tubercles, those nearest the ventral margin being the larger. There are three small ventral ridges, the two near the ventral margin are smaller and almost confined to the anteroventral and mid-ventral regions. Anterior and posterior margins are denticulate. Viewed internally the valves are deep. *Duplicature* fairly wide, 0·11 mm. at the posterior extremity (Pl. 16, fig. 9). *Selvage* well-developed, subperipheral in the left valve but almost at the outer third in the right valve. A deep *flange groove*, better developed at the venter, lies between the selvage and flange in the right valve. *Radial pore canals* fairly numerous, simple, almost straight, few occurring in groups of two or three. *Inner margin* and *line* of *concrescence* coincide. *Muscle scars* (best seen in weathered specimens from the outside) are in an almost vertical column of four adductors and two more or less rounded frontal scars. Hinge holamphidont:

Element	Left valve	Right valve
Anterior	Deep, almost rounded socket bounded on all sides.	Highly projecting pessular tooth.
Anteromedian	Projecting subconical tooth.	Socket opening into posteromedian groove.
Posteromedian	Slightly projecting denticulate ridge (denticles are seen only in nicely preserved specimens).	Locellate groove.
Posterior	Deep elongate socket unbounded on venter.	Large subpessular tooth, less high on anterior.

Dimensions (mm).

		L	H	W
Io. 4328	Carapace male (holotype)	0·85	0·50	0·45
Io. 3134	Carapace female	0·83	0·51	0·48
Io. 3133	Left valve female	0·84	0·54	—
Io. 4277	Right valve female	0·83	0·50	—

Comparison. *Echinocythereis* (*Scelidocythereis*) *sparsa* sp. nov. is smaller than the present species, has a different lateral outline, distinct marginal rims and scattered tubercles as surface ornamentation. In addition to this, it has an indistinct rather than prominent subcentral-tubercle.

Remarks. This species occurs in the Upper Chocolate Clays of the Zao River and Rakhi Nala sections. It has a short vertical range and hence can be used as an index marker.

Echinocythereis (Scelidocythereis) sp.A

(Plate 17, figs. 3, 4, 8, 9)

Figured specimen. Io. 3129.

Material. Two specimens from the locality and horizon below.

Locality. Sor Range section.

Horizon. Upper Palaeocene, sample no. 460-i.

Description. *Carapace* short, subquadrate in lateral view. Dorsal margin slightly irregular due to surface ornamentation, ventral margin almost straight, anterior broadly and evenly rounded, posterodorsal margin straight, posterior extremity somewhat rounded, posteroventral margin curved. Greatest length lies below mid-point, greatest height in the anterior third and greatest width behind the middle. Anterior and posterior cardinal angles well-developed. Valves almost equal. *Eye-tubercle* rounded, polished and distinct. *Subcentral-tubercle* present but not well-developed. Surface reticulate with superimposed papillae. A weak ventral ridge at some distance from the ventral margin slopes obliquely upwards towards the

posterior end. The posterodorsal process is a short horn-like ridge slightly anterior to the posterior cardinal angle. A marginal rim runs along anterior, venter and posterior margins.

Dimensions (mm).

		L	H	W
Io. 3129	Carapace	0·59	0·39	0·34

Comparison. This species has already been compared with *Echinocythereis* (*Echinocythereis*) *contexta* sp. nov.

Echinocythereis (Scelidocythereis) rasilis sp. nov.

(Plate 17, figs. 5, 6, 10 ; Plate 18, figs. 1–3, 5, 7)

Derivation of name. Latin *rasilis*, smoothed ; with reference to the carapace.

Diagnosis. Carapace subreniform. Dorsal margin arched with a slight concavity behind the protruding anterior cardinal angle. Surface smooth with two ventral ridges.

Holotype. Io. 4329, a female carapace (Pl. 17, figs. 6 ; Pl. 18, figs. 2, 3).

Paratypes. Io. 4278 + Io. 3131–2.

Material. 17 specimens from the Rakhi Nala section from three horizons (sample nos. 3499, 3614 and 3617). 41 specimens from the Zao River section from seven horizons (sample nos. 24145, 24147, 24148, 24150, 24152 and 24157). GSP BM 2537–8.

Type locality. Rakhi Nala section.

Type horizon. Lower Chocolate Clays, sample no. 3499.

Description. *Carapace* subreniform in lateral outline, with the greatest height at the anterior cardinal angle. Dorsal margin arched with a slight concavity behind the anterior cardinal angle, ventral margin incurved anterior of the middle, particularly in the right valve ; anterior margin broadly rounded, posterodorsal slope very slightly concave, posterior extremity rounded, posteroventral margin curved or straight. In dorsal view the greatest width lies almost at the middle. Anterior and posterior marginal areas compressed. Anterior cardinal angle protruding, Right valve over-reaches left valve along the anterior and posteroventral margins. Left valve over-reaches right valve slightly in the regions of the anterior cardinal angle and posterodorsal slope. Surface smooth. There are two ventral ridges, the one nearest the ventral margin being smaller. *Eye-tubercle* more or less distinct and situated below the anterior cardinal angle. Anterior margin finely denticulate (20–25 small denticles), posterior with 6–8 larger denticles. *Duplicature* fairly wide, 0·073 mm. anteriorly. In the right valve the *selvage* and *flange groove* are well-developed particularly in the anteroventral and ventral regions. In the left valve the *selvage* is well-marked but the *flange groove* is somewhat less well-developed. *Radial pore canals* not clearly visible but would seem to be simple, straight and numerous. No *vestibule*. *Hinge* not determinable.

Dimensions (mm).

		L	H	W
Io. 4278	Carapace male	0·59	0·46	0·37
Io. 4329	Carapace female (holotype)	0·56	0·45	0·37
Io. 3131	Carapace male	0·76	0·49	0·37
Io. 3132	Carapace female	0·78	0·49	0·42

Comparison. *Hemicythere sahnii* Tewari and Tandon (1960) appears to be a closely related species. Specimens of this were not available for comparison but from the description and figures given by these authors it does not seem to have the concavity behind the anterior cardinal angle which is present in *E(S.) rasilis*, sp. nov.

Remarks. The marginal denticles are not preserved in all specimens.

Echinocythereis (Scelidocythereis) sparsa sp. nov.

(Plate 18, figs. 4, 6, 8, 9)

Derivation of name. Latin *sparsus*, scattered ; with reference to the papillae.

Diagnosis. A species of *Scelidocythereis* with subrectangular carapace, dorsal margin slightly arched, ventral margin incurved in front of the middle. Surface ornamented with scattered papillae and two ventral ridges. Anterior and posterior marginal rims distinct. Left valve larger than right.

Holotype. Io. 4330, a female carapace (Pl. 18, figs. 8, 9).

Paratype. Io. 4279.

Material. 43 specimens from the locality below from three horizons (sample nos. 24159, 24181, and 24183). GSP BM 2539–40.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24159.

Description. Sexual dimorphy moderate, the males are longer in proportion than the females. *Carapace* subrectangular in side view with greatest height at the anterior cardinal angle. Dorsal margin slightly arched, ventral margin sinuated anterior to the middle. Anterior margin broadly rounded, posterior somewhat rounded. Right valve larger than left valve, which it over-reaches along the anterior and ventral margin. Anterior cardinal angle rounded. *Subcentral-tubercle* indistinct, *eye-tubercle* rounded and distinct. Surface ornamentation consists of sparsely distributed papillae. There are two ventral ridges ; the top ridge bifurcates posteriorly but the bottom ridge is shorter. Anterior and posterior marginal rim fairly well-developed. Anterior margin ornamented with small and numerous denticles, posterior with 6–8 larger denticles. *Duplicature* moderately wide with a prominent *selvage* and *flange-groove* in the right valve particularly in the ventral and anteroventral regions. *Radial pore canals* simple, almost straight, irregularly spaced, 25–30 anteriorly and 12–15 posteriorly. *Hinge* holamphidont : right valve with anterior tooth—conical and projecting, followed by postjacent socket, shallow posteromedian groove and posterior reniform tooth. *Muscle scar*

pattern consists of four adductors in a vertical superposition and two more or less rounded frontal scars.

Dimensions (mm).

		L	H	W
Io. 4279	Carapace male	0·78	0·45	0·37
Io. 4330	Carapace female (holotype)	0·76	0·49	0·39

Comparison. *Echinocythereis* (*Scelidocythereis*) *rasilia* sp. nov. although smaller than the present species may be ancestral but has a smooth rather than a papillose surface. Moreover, it has a concavity behind the anterior cardinal angle and lacks the distinct marginal rims.

Remarks. *Echinocythereis* (*Scelidocythereis*) *sparsa* has so far only been found in the Upper Chocolate Clays of the Zao River area.

Genus ***GYROCYTHERE*** nov.

Derivation of name. Greek *gyros*, circle ; with reference to the concentric arrangement of the ornamentation + *cythere*.

Diagnosis. Reticulate Trachyleberididae with three or four longitudinal ridges, the dorsal ridge distinct from the eye-tubercle, arcuate, sloping down towards anterior and terminating below the eye-tubercle ; the third ridge more or less distinct in different species.

Type species. *Gyrocythere exaggerata* sp. nov.

Description. Sexual dimorphism rather pronounced ; the females are shorter, higher and wider than the males. Carapace subrectangular to subquadrate in lateral view. Valves almost equal. Eye-tubercle and subcentral tubercle present, more or less pronounced. Surface reticulate. Three to four longitudinal ridges present ; the dorsal ridge commences anteriorly below the eye-tubercle and is arched convexly upwards ; the second ridge stretches backwards from the subcentral-tubercle and is also arched convexly upwards, its continuation in front of the subcentral-tubercle being less pronounced ; the third ridge situated below the subcentral-tubercle slopes obliquely upwards towards the posterior and is curved convexly downward towards the anterior and the ventral ridge is confined to the posterior two-thirds of the carapace and culminates in a slight alar expansion in the posterior, almost obsolete or absent in some species. Normal pores simple, fairly numerous. Radial pore canals simple, irregularly spaced, more or less straight, a few seem to bifurcate, approximately 25 anteriorly. Inner margin and line of concrescence coincide. Duplicature moderately wide. Selvage well-marked, submarginal in left valve but at some distance from the outer margin in right valve. Ventral and anterior flange grooves well-developed in right valve. Hinge holamphidont with stirpate anterior tooth in right valve. Muscle scar pattern consists of four adductor scars in an almost vertical row and a U-shaped frontal scar, which opens to the anterodorsal angle.

Comparison. This genus differs from the genus *Costa* in having an arcuate dorsal

ridge and in the less evident anterior marginal rim. Further, the subcentral-tubercle in *Costa* lies more towards the anterior. *Hermanites* has only two longitudinal ridges and has a concave posterodorsal slope. *Gyrocythere* lacks the very wide duplicature seen in *Paracytheretta*.

Gyrocythere exaggerata sp. nov.

(Plate 18, figs. 10–14 ; Plate 19, Plate 20, fig. 5)

Derivation of name. Latin *exaggeratus*, exaggerated ; with reference to the well-developed longitudinal ridges.

Diagnosis. A species of the genus *Gyrocythere* with prominent eye-tubercle, bilobate subcentral-tubercle and well-developed longitudinal ridges.

Holotype. Io. 4331, a female carapace (Pl. 19, figs. 1–4).

Paratypes. Io. 4280 + 3122–3128

Material. 39 specimens from the Zao River section from six horizons (sample nos. 24145, 24147, 24148, 24150 24152). Eight specimens from the Rakhi Nala section from two horizons (sample nos. 3613 and 3614). GSP BM 2541–2.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24151.

Description. *Carapace* subrectangular in the male dimorph and subquadrate in the female. Anterior margin broadly and evenly rounded, posterior narrow, almost rounded in left valve but slightly subangular in the right valve. Dorsal and ventral margins almost concealed in lateral outline by the dorsal and ventral ridges. Greatest height in the ocular region, greatest length passes through the mid-point. Anterior cardinal angle prominent with a concavity behind in lateral view. Valves almost equal. *Eye-tubercle* prominent, rounded and polished, stands out in lateral view. *Subcentral-tubercle* distinct and bilobate. Surface coarsely reticulate. Reticulae are slightly papillose in some specimens. There are four well-developed longitudinal ridges ; the dorsal ridge begins below the eye-tubercle anteriorly and is convex upwards, whilst the median or second ridge runs from the subcentral-tubercle posteriorly and is convex upwards, its extension anterior to the subcentral-tubercle is less well-marked. A third ridge is intercalated between the median and the ventral ridges. It slopes obliquely upwards towards the posterior and is convex downwards in its anterior part. The ventral ridge is restricted to the posterior two-thirds of the carapace. It ends in a slight alar expansion in the posterior third of the carapace. Anterior margin denticulate, posteroventral margin with short spines present in some specimens. *Normal pore canals* simple, numerous (Pl. 19, figs. 6, 7). *Radial pore canals* not very well-displayed due to the form of preservation, but appear to be simple, almost straight, irregularly spaced (few seem to bifurcate), with some 25 at the anterior margin. *Line of concrescence* and *inner margin* coincide. *Duplicature* of moderate width, 0·07 mm. anteriorly. *Selvage* pronounced in both valves ; it is in the outer third of the duplicature in right valve but submarginal in left valve. Right valve with well-developed *flange groove*, particularly on the venter. *Muscle scars* are

in a vertical row of four adductors and a U-shaped frontal scar opening towards the anterodorsal corner. *Hinge* holamphidont :

Element	Left valve	Right valve
Anterior	Rounded socket, confluent with ocular sinus, seen in a few specimens.	Projecting stirpate tooth.
Anteromedian	Subconical tooth which has straight anterior but convex posterior in dorsal view.	Deep rounded socket opening into postero-median groove.
Posteromedian	Denticulate bar.	Locellate groove.
Posterior	Deep, slightly elongate socket.	Pessular tooth, but sub-rectangular in lateral view.

Dimensions (mm).

		L	H	W
Io. 3125	Left valve male	0·81	0·49	—
Io. 3127	Right valve male	0·83	0·49	—
Io. 4331	Carapace female (holotype)	0·78	0·49	0·46
Io. 3126	Left valve male	0·76	0·46	—
Io. 3124	Right valve female	0·71	0·44	—
Io. 3128	Right valve female	0·71	0·44	—
Io. 4280	Left valve male	0·77	0·46	—
Io. 3120	Right valve female	0·72	0·44	—
Io. 3122	Right valve male	0·79	0·44	—

Comparison. This species resembles *Gyrocythere perfecta* sp. nov. (Pl. 22, figs. 1–10) but differs from it in being larger and having more prominent longitudinal ridges and an eye-tubercle. Moreover, the subcentral tubercle in *G. exaggerata* is distinctly bilobate.

Remarks. The occurrence of this species ranges through 390 ft. in the Zao River section and 15 ft. in the Rakhi Nala section. It seems likely that it will prove a useful horizon marker.

Gyrocythere parvicarinata sp. nov.

(Plate 20, figs. 1–4, 6–8, 12)

Derivation of name. Latin *parvus*, little + *carinatus*, ridged; with reference to the longitudinal ridges.

Diagnosis. A strongly reticulate species of the genus *Gyrocythere* with three longitudinal ridges, median ridge ill-defined, posterior subtriangular, eye-tubercle distinct, subcentral-tubercle well-developed.

Holotype. Io. 4334, a male carapace (Pl. 20, figs. 1, 2, 6, 7).

Paratype. Io. 4281.

Material. Over 100 specimens from the Rakhi Nala section from 25 horizons (sample nos. 3153, 3168 to 3172, 3179, 3180, 3185, 3192, 3193, 3199, 3200, 3401 to 3405, 3407, 3409, 3410, 3415 and 3417). GSP BM 2543–4.

Type locality. Rakhi Nala section.

Type horizon. Green and Nodular Shales, sample no. 3407.

Description. Sexual dimorphism distinct ; the males are more elongate than the females. *Carapace* subrectangular in side view. Anterior margin broadly rounded, posterior subtriangular. Dorsal margin straight but appears slightly convex in lateral view due to the over-reaching of the dorsal ridge, ventral margin slightly concave in front of the middle. Anterior cardinal angle distinct with a concavity behind in lateral view. Left valve slightly over-reaches right valve at anterior cardinal angle and posterodorsal slope. In dorsal view the greatest width lies in the anterior two-fifths. *Subcentral-tubercle* well developed. *Eye-tubercle* distinct. Surface strongly reticulate with three longitudinal ridges ; the dorsal ridge is curved convexly upwards ; the median ridge is more or less ill-defined in many specimens ; the third or ventral ridge is curved convexly downward anteriorly. Anterior and posterior marginal rims present but not high. Both anterior and posterior margins are denticulate. *Duplicature* of medium width. *Selvage* distinct and at some distance from the outer margin in right valve. Anterior and ventral *flange grooves* well-developed in right valve. *Radial pore canals* not clearly seen due to mineralization. *Hinge* as for the genus.

Dimensions (mm).

		L	H	W
Io. 4334	Carapace male (holotype)	0·68	0·37	0·34
Io. 4281	Carapace female	0·67	0·42	0·37

Comparison. This species is smaller than *Gyrocythere grandilaevis* sp. nov. Although the longitudinal ridges are no better developed than *G. grandilaevis* the eye-tubercle and subcentral-tubercle are more prominent, the reticulation is deeper and wider in proportion.

Gyrocythere grandilaevis sp. nov.

(Plate 20, figs. 9–11, 13 ; Plate 21, figs. 1–4)

Derivation of name. Latin *grandis*, large + *laevis*, smooth ; with reference to the carapace.

Diagnosis. A species of *Gyrocythere* with large, reticulate, smooth carapace. Three longitudinal ridges, including median ridge which is not well-developed. Anterior and posterior marginal rims distinct.

Holotype. Io. 4332, a female carapace (Pl. 20, figs. 11, 13 ; Pl. 21, figs. 3, 4).

Paratype. Io. 4282.

Material. 16 specimens from the locality below from four horizons (sample nos. 3463 to 3466). Two specimens from the Shpalai Khwara section from one horizon (sample no. 24692). GSP BM 2545–6.

Type locality. Rakhi Nala section.

Type Horizon. Shales with Alabaster, sample no. 3463.

DESCRIPTION. Sexual dimorphism moderate ; the males are proportionally longer than the females. *Carapace* subrectangular in lateral outline. Anterior margin broadly rounded, posterior margin almost rounded in left valve but with a slight concavity in the posterodorsal slope of the right valve. Dorsal margin almost straight but appears slightly convex in lateral view due to the dorsal ridge, which slightly over-reaches it ; ventral margin slightly concave in front of the middle. Valves almost equal. *Subcentral-tubercle* and *eye-tubercle* present but not pronounced. Surface reticulate ; the reticulae concentrically arranged around the subcentral-tubercle. There are three longitudinal ridges, a dorsal ridge curved convexly upward, a median or second less well-developed ridge and a ventral or third ridge which runs obliquely from above the anteroventral corner towards the posterior and is curved convexly downward in its anterior portion. Anterior and posterior marginal rims distinct. Anterior and posterior margins denticulate. Internal features not seen.

DIMENSIONS (mm).

		L	H	W
Io. 4332	Carapace male (holotype)	0·85	0·46	0·44
Io. 4282	Carapace female	0·83	0·46	0·46

COMPARISON. This species resembles *Gyrocythere parvicarinata* sp. nov. but differs from it in being larger. Moreover, the posterior in *G. parvicarinata* is subacuminate. *G. grandilaevis* is perhaps ancestral to *Gyrocythere perfecta* sp. nov. which is smaller and has stronger ornamentation.

Gyrocythere mitigata sp. nov.

(Plate 21, figs. 5–11)

DERIVATION OF NAME. Latin *mitigatus*, mellowed ; with reference to the ornamentation, less emphatic than in the typical species of *G. exaggerata*.

DIAGNOSIS. A large, strongly reticulate species of the genus *Gyrocythere* with three longitudinal ridges, the median ridge almost ill-defined.

HOLOTYPE. Io. 4333, a male carapace (P. 21, figs. 5–8).

PARATYPES. Io. 4283 + Io. 3119.

MATERIAL. 9 specimens from the locality below from two horizons (sample nos. 24131 and 24132). Io. 4283. GSP BM 2547–8.

TYPE LOCALITY. Zao River section.

TYPE HORIZON. Lower Chocolate Clays, sample no. 24131.

DESCRIPTION. Sexually dimorphic ; the males are longer than the females. *Carapace* subrectangular in lateral view. Anterior margin broadly and evenly rounded, dorsal margin almost straight in reality but appears slightly convex in lateral view because of the over-reaching of the dorsal ridge ; posterodorsal slope very slightly concave particularly in the right valve, posterior extremity rounded, posteroventral margin curved, ventral margin almost straight. Greatest height in the anterior quarter, greatest length almost in the middle. Anterior and posterior

cardinal angles well-marked, particularly in left valve. Left valve slightly overreaches the right valve in the anterodorsal corner and at the posterodorsal slope. Greatest width in dorsal or ventral view lies in the posterior third. *Subcentral-tubercle* prominent, *eye-tubercle* rounded and distinct. Surface strongly reticulate with three longitudinal ridges : the dorsal ridge is curved convexly upwards in the middle and starts anteriorly below the eye-tubercle ; the median ridge is less well-developed, almost ill-defined in most specimens ; it runs posteriorly from the subcentral-tubercle and is curved convexly upwards. The ventral ridge commences anteriorly above the anteroventral corner and runs obliquely upwards towards the posterior and culminates in the posterior third. Marginal rim is distinct at the anterior and posterior but less distinct along the venter. Anterior margin denticulate, posterior extremity and posteroventral margin ornamented with about six short spines or papillae. *Duplicature* of moderate width. *Selvage* well-developed, subperipheral in the left valve but situated at some distance from the outer margin in the right valve. The right valve has a fairly deep *flange groove* along the venter and around the anterior margin. *Hinge* as for the genus.

Dimensions (mm).

		L	H	W
Io. 4333	Carapace male (holotype)	0·88	0·49	0·49
Io. 4283	Carapace female	0·83	0·49	—
Io. 3119	Left valve female	0·80	0·47	—

Comparison. *Gyrocythere grandilaevis* sp. nov. is somewhat similar to the present species and might even be ancestral although *G. grandilaevis* is smaller and has a less well-developed subcentral-tubercle. The dorsal and ventral ridges in *G. grandilaevis* are also less well-marked. *G. mitigata* differs from *Gyrocythere exaggerata* sp. nov. in being larger, having a different lateral outline and less emphatic ornamentation. Further, *G. mitigata* has three, rather than four longitudinal ridges and lacks a bilobate subcentral-tubercle.

Remarks. *G. mitigata* has so far only been found in the Zao River section, where it occurs at two horizons.

Gyrocythere perfecta sp. nov.

(Plate 22, figs. 1–10)

Derivation of name. Latin *perfectus*, perfect ; with reference to the beauty of the material.

Diagnosis. *Gyrocythere* with strongly reticulate, concentrically arranged ornamentation. Eye-tubercle, subcentral-tubercle and longitudinal ridges distinct.

Holotype. Io. 4335, a female carapace (Pl 22, figs. 3, 4, 7, 8).

Paratypes. Io. 4284 + Io. 3120–1.

Material. 20 specimens from the locality below from two horizons (sample nos. 3498 and 3499). GSP BM 2548–50.

Type locality. Rakhi Nala section.

Type horizon. Lower Chocolate Clays, sample no. 3499.

DESCRIPTION. *Carapace* subrectangular in lateral view, arrow-shaped in ventral view. Sexual dimorphism rather pronounced ; the females are higher and wider than the males. Anterior margin broadly rounded, posterior slightly subangular, particularly in the right valve. Dorsal margin straight but appears to be convex due to the over-reaching of the dorsal ridge ; ventral margin slightly concave anterior to the middle. Anterior cardinal angle distinct and rounded. Valves almost equal. *Eye-tubercle* distinct but not high. *Subcentral-tubercle* distinct, slightly lobate. Surface strongly and deeply reticulate, the reticulation being concentric around the subcentral-tubercle. Four longitudinal ridges occur : the dorsal ridge is convex upwards ; it commences below the eye-tubercle and culminates in the posterodorsal region ; the median or second ridge is also convex upwards ; it runs from the subcentral-tubercle towards the posterior but its continuation anterior to the subcentral-tubercle is not distinct ; the third ridge is convex downwards in its anterior half and slopes obliquely upwards towards the posterior ; the ventral ridge is better seen in ventral view ; it is confined in the posterior three-quarters. Anterior margin denticulate. There is a short posteroventral spine present in most specimens. *Radial pore canals* simple, more or less straight, irregularly spaced, few seem to bifurcate, about 25–28 in the anterior. *Inner margin* and *line of concrescence* coincide throughout. *Duplicature* moderately wide with a distinct *selvage*. In the right valve the selvage lies at some distance from the outer margin and the anterior and ventral flange grooves are distinct. *Adductor scars* in a vertical column of four and with a U-shaped frontal scar. *Hinge* holamphidont.

DIMENSIONS (mm).

		L	H	W
Io. 4281	Carapace male	0·71	0·39	0·38
Io. 4335	Carapace female (holotype)	0·71	0·42	0·42
Io. 3121	Right valve male	0·76	0·42	0·42
Io. 3121	Right valve female	0·76	0·42	—
Io. 3120	Right valve female	0·76	0·44	—

COMPARISON. The present species is similar in all characters to *Gyrocythere exaggerata* sp. nov. but is smaller and with a less well-marked ornamentation. On the other hand, the ornamentation is stronger than in *Gyrocythere grandilaevis* sp. nov. In both the morphological development and stratigraphical position, *G. perfecta* falls between *G. grandilaevis* and *G. exaggerata*.

REMARKS. *G. perfecta* has so far only been found in the type locality.

Genus ***HERMANITES*** Puri 1955

TYPE SPECIES. *Hermania reticulata* Puri 1954.

Hermanites cracens sp. nov.

(Plate 22, figs. 11 ; Plate 23, figs. 1–3)

DERIVATION OF NAME. Latin *cracens*, graceful ; with reference to the pleasing curve of the ridges.

Diagnosis. A large *Hermanites* with well-developed slightly curved dorsal and ventral ridges. Subcentral-tubercle prominent with three small curved longitudinal ridges behind.

Holotype. Io. 4336, a carapace.

Material. Only one specimen from the locality and horizon below.

Type locality. Rakhi Nala section.

Type horizon. Gorge Beds, sample no. 3111.

Description. *Carapace* large, massive, subrectangular in lateral view. Greatest length through the mid-point, greatest height through the anterior cardinal angle and greatest width in the posterior third. Dorsal and ventral margins almost straight, anterior broadly and evenly rounded, posterodorsal margin very slightly concave, posteroventral margin and posterior extremity rounded. Anterior cardinal angle well-developed particularly in the left valve. Left valve slightly over-reaches the right at the anterior cardinal angle and posterodorsal slope. *Subcentral tubercle* prominent. *Eye-tubercle* rounded and distinct and with a rounded groove in front, particularly in the left valve. Marginal rim high in the anterior but somewhat less high in the posterior and venter. Surface coarsely reticulate with well-marked, dorsal and ventral ridges ; the dorsal ridge commences above the subcentral-tubercle and is slightly curved convexly upwards ; the ventral ridge slopes obliquely upward towards posterior and then curves sharply round towards posteroventral margin in posterior quarter. There are three short curved longitudinal ridges behind the subcentral-tubercle, the bottom one being the shortest. Anterior and posterior margins spinose—anterior with numerous small spines but posterior with few larger spines.

Dimensions (mm).

		L	H	W
Io. 4336	Carapace	0·95	0·51	0·51

Comparison. *Hermanites palmatus* sp. nov. is much smaller, has the dorsal and ventral ridges joined posteriorly by a transverse ridge and the ridges in front of the subcentral-tubercle have a palmate appearance.

Remarks. So far only one specimen of this species has been recovered from the Gorge Beds of the Rakhi Nala section, where it occurs in association with *Alocopocythere rupina* sp. nov. and *Buntonia devexa* sp. nov.

Hermanites scopus sp. nov.

(Plate 23, figs. 4–10)

Derivation of name. Latin *scopus*, target ; in allusion to the fancied resemblance of the ornamentation to a bull's-eye.

Diagnosis. A species of the genus *Hermanites* in which ventral ridge curves downward in the middle and is joined by a short vertical ridge at its posterior end ; surface

coarsely reticulate with prominent subcentral-tubercle from which a ridge runs towards anterior margin.

HOLOTYPE. Io. 4338, a male carapace (Pl. 23, figs. 4–7).

PARATYPE. Io. 4285.

MATERIAL. 13 specimens from the Rakhi Nala section from six horizons (sample nos. 3499, 3610, 3613 to 3615 and 3618). Two specimens (including holotype) from the Zao River section from two horizons (sample nos. 24148 and 24150). GSP BM 2552–3.

TYPE LOCALITY. Zao River section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 24148.

DESCRIPTION. Sexual dimorphy observed ; the males are longer in proportion than the females. *Carapace* thick-shelled, sub-rectangular in lateral view. Anterior margin broadly and evenly rounded, posterior slightly subtriangular. Dorsal and ventral margins almost straight. Valves more or less equal. Anterior cardinal angle well-developed. In dorsal view, greatest width lies in the posterior third. *Eye-tubercle* rounded and prominent with rounded deep groove in front (better seen in dorsal view). *Subcentral-tubercle* prominent with a ridge running towards the anterior margin. Surface strongly reticulate (occasionally with superimposed rounded spines particularly at the junction where two reticulae meet). Dorsal and ventral ridges well-developed : the dorsal ridge is almost straight while the ventral ridge is curved convexly downward in the middle culminating in a short vertical ridge in the posterior third. Anterior and posterior marginal rims elevated, ventral marginal rim somewhat less elevated. Anterior and posterior margins ornamented with double row of spines (not preserved in all specimens)—one row of spines lies on the anterior and posterior marginal rims and the second row below these rims. *Duplicature* of moderate width with subperipheral selvage. *Radial pore canals* and *muscle scars* not known. *Hinge* holamphidont : left valve hinge consists of two terminal sockets, median element subdivided into anteromedian subconical projecting tooth and denticulate bar ; right valve hinge (seen only in a broken valve) consists of a stirpate, projecting anterior tooth, deep anteromedian socket, locellate posteromedian groove and posterior tooth (broken).

DIMENSIONS (mm).

		L	H	W
Io. 4338	Carapace male (holotype)	0·78	0·44	0·44
Io. 4285	Carapace female	0·81	0·46	0·49

COMPARISON. This species shows some resemblance to *Hermanites cracens* sp. nov. but is smaller, has a more curved ventral ridge culminating in a short vertical ridge in the posterior third and lacks the three small, curved longitudinal ridges behind the subcentral-tubercle.

REMARKS. *Hermanites scopus* rarely occurs in the Lower and Upper Chocolate Clays of the Rakhi Nala and Zao River sections and can easily be recognized by its characteristic ventral ridge.

Hermanites palmatus sp. nov.

(Plate 24, figs. 1–9, 11, 12)

Derivation of name. Latin *palmatus*, palmate ; with reference to the palmate appearance of the ridges in front of the subcentral-tubercle.

Diagnosis. *Hermanites* in which dorsal and ventral ridges are alate and joined posteriorly by a transverse ridge which is slightly concave towards posterior. Subcentral-tubercle prominent with palmate appearance of ridges in front.

Holotype. Io. 4337, a female left valve (Pl. 24, figs. 6, 8, 9, 11).

Paratypes. Io. 4286 + Io. 3117–8.

Material. 9 specimens from the Rakhi Nala section from five horizons (sample nos. 3613 to 3615, 3617 and 3618). 17 specimens from the Zao River section from four horizons (sample nos. 24131, 24150, 24152 and 24156). GSP BM 2554–5.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24152.

Description. Sexual dimorphism apparent ; the females being shorter than the males. *Carapace* subrectangular in lateral outline with greatest height in the region of the anterior cardinal angle. Dorsal and ventral margins almost straight, anterior margin broadly rounded, posterodorsal corner very slightly concave, posterior extremity and posteroventral margin rounded. Valves almost equal. *Subcentral-tubercle* prominent. *Eye-tubercle* rounded and distinct. Surface recticulate with alate dorsal and ventral ridges which are joined posteriorly by a transverse ridge which is slightly concave towards the posterior. Anterior and posterior marginal platforms compressed. Anterior and posterior marginal rims distinct. Anterior margin ornamented with 20–25 small spines, posterior with 6–8 larger spines. *Duplicature* of moderate width, 0·050 mm. anteriorly. Both valves have a distinct *selvage*. *Hinge* holamphidont : left valve hinge with fairly deep anterior socket, anteromedian tooth rounded, subconical (slightly projecting towards the anterior in dorsal view), posteromedian ridge denticulate and deep, slightly elongate posterior socket ; right valve hinge with anterior subconical, projecting tooth followed by deep postjacent socket, posteromedian shallow groove and an almost rounded, posterior tooth.

Dimensions (mm).

		L	H	W
Io. 4286	Carapace male	0·69	0·37	0·37
Io. 3117	Carapace female	0·63	0·37	0·37
Io. 4337	Left valve female (holotype)	0·73	0·40	—
Io. 3118	Left valve female	0·73	0·44	—

Comparison. *Hermanites scopus* sp. nov. is larger, has a curved ventral ridge and subtriangular posterior margin. *Hermanites indicus* Tewari and Tandon (1960) has a subtriangular posterior end and lacks the transverse ridge which posteriorly joins the dorsal and ventral ridges. The Miocene species *Hermanites purii* Tewari and Tandon (1960) has somewhat similar lateral outline, but lacks both the transverse

ridge which posteriorly joins the dorsal and ventral ridges and the palmate appearance of ridges in front of the subcentral-tubercle. Moreover, the greatest width in *Hermanites palmatus* is in the posterior third, but in *Hermanites purii* it is a little to the anterior of the middle (see Tewari and Tandon, p. 158).

Remarks. The true relationship of the present species with *Hermanites indicus* and *Hermanites purii* cannot be determined until topotype material from Kutch is available for comparison.

Genus ***OCCULTOCYTHEREIS*** Howe 1951

Type species. *Occultocythereis delumbata* Howe 1951.

Occultocythereis interrupta sp. nov.

(Plate 24, figs. 10, 13–18)

Derivation of name. Latin *interruptus*, broken apart ; with reference to the break in the dorsal ridge.

Diagnosis. A small *Occultocythereis* with well-marked subangular posterodorsal process which is confluent with four ridges including an oblique ridge running towards posteroventral region and then extending towards anteroventral corner as an oblique ventral ridge.

Holotype. Io 4339, a female carapace (Pl. 24, figs. 14, 17, 18).

Paratype. Io. 4287.

Material. 28 specimens from the locality below from three horizons (sample nos. 460-f, 460-i and 460-j). GSP BM 2556–7.

Type locality. Sor Range section.

Type horizon. Upper Palaeocene, sample no. 460-i.

Description. Sexual dimorphism marked ; the females are shorter and wider than the males. *Carapace* subrectangular in side view, tapering towards the posterior. Dorsal and ventral margins almost straight ; the dorsal margin appears slightly irregular in lateral outline because of the over-reaching of the dorsal ridge ; anterior margin broadly and obliquely rounded, posterior narrow, slightly concave in posterodorsal slope but more or less rounded in posteroventral margin. Greatest length lies through the mid-point and greatest height at the anterior cardinal angle. Anterior and posterior cardinal angles well-marked particularly in the right valve. Valves almost equal. *Eye-tubercle* distinct, situated on the anterior marginal rim. Shell surface undulating with compressed anterior and posterior platforms. A well-marked, subangular posterodorsal process is confluent with four ridges : (1) a short ridge extends vertically towards the posterodorsal corner ; (2) a dorsal ridge runs towards the anterior, culminating in the anterior third of the dorsal margin—it is slightly convex upwards ; (3) a short ridge extends vertically below, terminating before reaching the mid-line, whilst the fourth ridge runs obliquely towards the posteroventral region where it is joined by an oblique ventral ridge running towards

the anteroventral corner. Anteromedian swelling well-developed. A marginal rim extends around the anterior, ventral and posterior margins, elevated on the anterior margin but less elevated around the venter and posterior. Small ridges run between the anterior marginal rim and the anterior margin (these are better seen in ventral view). Four to five short spines ornament the posteroventral margin. Internal details not known.

Dimensions (mm.)

	L	H	W
Io. 4287 Carapace male	0·39	0·18	0·11
Io. 4339 Carapace female (holotype)	0·38	0·20	0·13

Comparison. *Occultocythereis indistincta* sp. nov. is much larger, has a continuous rather than a broken dorsal ridge and lacks the oblique posterior ridge which joins the posterodorsal process and the ventral ridge.

Remarks. *O. interrupta* is so far only known from the Upper Palaeocene of the Sor Range section.

Occultocythereis Sp.A

(Plate 25, figs. 1, 2, 5, 12)

Figured specimen. Io. 3136.

Material. Only one specimen from the locality and horizon below.

Locality. Rakhi Nala section.

Horizon. Lower Rakhi Gaj Shales, sample no. 3672.

Description. *Carapace* subrectangular with ventral inflation. Dorsal and ventral margins almost straight, tapering towards the posterior ; anterior margin broadly and obliquely rounded, posterior narrowly rounded with a slight concavity in the posterodorsal corner. Greatest length runs through the middle, greatest height in the anterior two-fifths and greatest width in the posterior third. Anterior and posterior cardinal angles rounded. Valves almost equal. *Eye-tubercle* distinct but low. *Subcentral-tubercle* weak. Surface reticulate. Posterodorsal process consists of a more or less rounded tubercle which extends anteriorly in a weak dorsal ridge. Anterior marginal rim well-marked, ventral and posterior marginal rims less elevated. Posterior ornamented with 4–5 short spines.

Dimensions (mm).

		L	H	W
Io. 3136	Carapace	0·42	0·22	0·17

Remarks. This species differs from other known species of the genus *Occultocythereis* in its obliquely rounded anterior margin.

Occultocythereis spilota sp. nov.

(Plate 25, figs. 3, 4, 6–11)

Derivation of name. Greek *spilotos*, spotted ; with reference to the largish puncta.

DIAGNOSIS. A species of *Occultocythereis* in which surface is ornamented with largish puncta. Posteroventral margin rounded, posteroventral process a short slightly oblique ridge well-developed in female, ill-defined in male, anteroventral swelling small.

HOLOTYPE. Io. 4342, a female carapace (Pl. 25, figs. 6, 7, 10, 11).

PARATYPE. Io. 4288.

MATERIAL. Four specimens from the locality below from three horizons (sample nos. 3173, 3174 and 3177). GSP BM 2558–9.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Green and Nodular Shales, sample no. 3177.

DESCRIPTION. Dimorphic ; the females are higher and wider than the males. *Carapace* subrectangular in lateral view with greatest length in the middle and greatest height in the anterior third. Anterior margin broadly rounded, posterodorsal slope very slightly concave, posteroventral margin rounded, dorsal and ventral margins almost straight, very slightly converging towards the posterior. Anterior cardinal angle rounded, posterior cardinal angle distinct about 110°. Valves almost equal. In dorsal view the greatest width lies in the posterior third. *Eye-tubercle* more or less distinct. *Subcentral-tubercle* present but not pronounced with a small swelling below and slightly anterior to it. Surface ornamented by large puncta. The posterodorsal process is a short projecting ridge extending vertically towards the mid-line but not reaching it. It extends anteriorly in a short dorsal ridge terminating in the anterior third of the dorsal margin. The posteroventral process is a short slightly oblique ridge lying in the posteroventral swelling. In the male dimorph the posteroventral swelling is less well-developed and the posteroventral ridge ill-defined. Anterior marginal rim prominent, ventral and posterior marginal rims less prominent. Anterior marginal area ornamented by numerous, short ridges lying between the rim and the margin. Posteroventral margin decorated by four to five short spines.

DIMENSIONS (mm).

		L	H	W
Io. 4288	Carapace male	0·38	0·21	0·13
Io. 4342	Carapace female (holotype)	0·38	0·22	0·16

COMPARISON. *Occultocythereis peristicta* sp. nov. Morphotype C is larger, has a vertical rather than an oblique posteroventral ridge joining the second posterior tubercle and the ventral ridge. Further, it lacks the dorsal ridge and the short ridges between the anterior rim and the anterior margin.

Occultocythereis peristicta sp. nov.

(Plate 25, figs. 13–17 ; Plate 26 ; Plate 27, figs. 1–2)

DERIVATION OF NAME. Greek *peristiktos*, punctate or dappled.

DIAGNOSIS. A punctate group of morphotypes of the genus *Occultocythereis* with-

out a dorsal ridge, ventral ridge well-marked, anteromedian swelling distinct, posterodorsal tubercle present.

HOLOTYPE. Io. 4341, a female carapace (Pl. 25, figs. 15) ; (Pl. 26, figs. 2, 3).

PARATYPES. Io. 4289–93 + Io. 3137–40.

MATERIAL. Approximately 800 specimens from the Rakhi Nala section from 42 horizons (sample nos, 3160, 3163, 3167, 3170, 3171, 3173, 3174, 3177, 3179, 3180, 3186–3194, 3197 to 3200, 3401 to 3405, 3407, 3409, 3410, 3415, 3418 to 3423, 3428, 3432, 3434 and 3435). GSP BM 2560–65.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Upper Rakhi Gaj Shales, sample no. 3167.

DESCRIPTION. Sexual dimorphism rather pronounced, the males are longer in proportion than the females. *Carapace* subrectangular or wedge-shaped in lateral outline. Dorsal and ventral margins almost straight, tapering towards the posterior, anterior margin broadly and evenly rounded, posterior narrow, slightly subangular in the middle or almost rounded. Greatest length passes through the middle, greatest height lies at the anterior cardinal angle which is fairly well-developed. Left valve slightly over-reaches the right valve at the anterior cardinal angle and in the region of the posterodorsal slope. *Eye-tubercle* rounded and distinct, lying on the anterior marginal rim. Subcentral or anteromedian swelling distinct, either elongate or almost rounded (elongate in most morphotypes). There is no dorsal ridge. Ventral ridge fairly well-developed, short in most morphotypes, either almost straight or runs slightly obliquely towards the posterior end where it may be connected to the second posterior tubercle or to the posterodorsal tubercle by means of a short vertical ridge. A dorsal ridge runs between the second posterior tubercle and the anteromedian swelling in some morphotypes. Anterior marginal rim high, ventral marginal rim less distinct, posterior marginal rim distinct. Short spines decorate the anterior and posterior margins.

Trends of variants :—

1. Become sparsely punctate.
2. Gain second posterior tubercle, which may join either the posterodorsal tubercle or the ventral ridge.
3. Become wedge-shaped.

REMARKS. *O. peristicta* commonly occurs in the Upper Rakhi Gaj Shales, Green and Nodular Shales and Rubbly Limestones of the Rakhi Nala section.

This species may be divided into the following morphotypes :

MORPHOTYPE A

(Pl. 25, figs. 13–17 ; Pl. 25, figs. 1–3).

This has a well-delimited vertical posterodorsal tubercle. There is no second posterior tubercle. The anteromedian swelling is less well-developed. The ventral

ridge is almost straight, short, confined in the mid-ventral region. The surface is densely punctate.

Dimensions (mm).

		L	H	W
Io. 4292	Carapace male	0·43	0·22	0·11
Io. 4341	Carapace female (holotype)	0·42	0·23	0·16

Morphotype B

(Pl. 26, figs. 4–9)

This is close to Morphotype A but has a more sparsely punctate surface and a second posterior tubercle. In addition, the present morphotype has a well-developed, somewhat elongate anteromedian swelling.

Dimensions (mm).

		L	H	W
Io. 4293	Carapace male	0·44	0·22	0·15
Io. 4291	Carapace female	0·40	0·22	0·16

Morphotype C

(Pl. 26, figs. 10–15)

This has a higher carapace than the other morphotypes. The ventral ridge runs slightly obliquely towards the posterior. It is joined posteriorly to the second posterior tubercle by a short vertical ridge. The anteromedian swelling and the second posterior tubercle form a broken diagonal ridge.

Dimensions (mm).

		L	H	W
Io. 4289	Carapace male	0·45	0·26	0·17
Io. 4290	Carapace female	0·44	0·25	0·18

Morphotype D

(Pl. 27, figs. 1–6)

The carapace is much more elongate than Morphotype A, B, C and E. The dorsal and ventral margins taper very slightly towards the posterior. An oblique posterior ridge joins the posterodorsal tubercle, the second posterior tubercle and the posterior end of the ventral ridge. The ventral ridge commences above the anteroventral corner, slopes obliquely upwards towards the posterior and meets the oblique posterior ridge in the posterior quarter. A diagonal ridge which may or may not be continuous passes through the second posterior tubercle and the anteromedian swelling.

Dimensions (mm).

		L	H	W
Io. 3146	Carapace male	0·51	0·24	0·16
Io. 3139	Carapace female	0·51	0·24	0·17

MORPHOTYPE E

(Pl. 27, figs. 7–12)

This is very similar to Morphotype B, but has a wedge-shaped carapace.

DIMENSIONS (mm).

		L	H	W
Io. 3137	Carapace male	0·39	0·20	0·13
Io. 3138	Carapace female	0·37	0·20	0·13

Occultocythereis indistincta sp. nov.

(Plate 27, figs. 13–15 ; Plate 28, figs. 1–4)

DERIVATION OF NAME. Latin *indistinctus*, dim or obscure ; named from the absence of well-marked diagnostic characters.

DIAGNOSIS. A species of the genus *Occultocythereis* with a well-developed dorsal ridge ending posteriorly in a large subangular posterodorsal process, ventral ridge oblique running from anteroventral corner towards posterior, surface ornamentation consists of indistinct puncta.

HOLOTYPE. Io. 4340, a female carapace (Pl. 27, figs. 15 ; Pl. 28, figs. 1, 3, 4).

PARATYPES. Io. 4294 + Io. 3135.

MATERIAL. 44 specimens from the locality below from seven horizons (sample nos. 3499, 3614, 3615, 3621, 3625, 3648 and 3649). GSP BM 2566–7.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Lower Chocolate Clays, sample no. 3499.

DESCRIPTION. Sexual dimorphism apparent ; the males are more elongate, less high and less wide than the females. *Carapace* subrectangular, slightly tapering towards the posterior. Dorsal margin straight but irregular in side view due to the over-reaching of the dorsal ridge, ventral margin almost straight, anterior margin broadly and evenly rounded, posterior narrow, subangular in the middle with slightly concave posterodorsal slope. Greatest length lies in the middle, greatest height in the anterior third. Anterior cardinal angle well-developed particularly in left valve, posterior cardinal angle rounded in the right valve but pointed in left valve. Left valve over-reaches right valve in the region of anterior cardinal angle and posterodorsal slope. *Eye-tubercle* distinct. Surface ornamented with small, indistinct puncta. Anteromedian swelling (which perhaps represents a subcentral-tubercle) distinct. A well-marked dorsal ridge commences behind the eye-tubercle and is slightly convex upward in the middle terminating in a large subangular posterodorsal process. In most specimens it is ornamented with three small tubercles which lie at some distance from one another. Ventral ridge runs obliquely from the anteroventral corner towards the posterior, culminating in the posterior third. (In some specimens it is not well-developed). A small tubercle is present in the postero-

median part of the carapace (halfway between the dorsal and ventral ridges) in a few specimens. A high marginal rim runs round the anterior extending along the venter and posterior as a less high rim. Anterior and posterior margins ornamented with short spines. *Duplicature* wide in anterior and posteroventral regions. *Selvage* distinct and lies at some distance from the outer margin. *Radial pore-canals* and *muscle scars* not determinable. *Hinge* as for the genus.

Comparison. *Occultocythereis mutabilis abducta* Triebel (1961) is very similar, but is larger, has a different posterior end, less well-developed subcentral-swelling and posterodorsal tubercle. *Occultocythereis mutabilis mutabilis* Tiebel (1961) has a vertical posteroventral ridge in the right valve of the male and in both valves of the females.

Dimensions (mm).

		L	H	W
Io. 4294	Right valve male	0·47	0·24	—
Io. 3135	Carapace male	0·43	0·22	0·13
Io. 4340	Carapace female (holotype)	0·43	0·24	0·16

Remarks. *O. indistincta* has so far been found in the Lower and Upper Chocolate Clays of the Rakhi Nala section.

Genus ***PATAGONACYTHERE*** Hartmann 1962

Type species. *Patagonacythere tricostata* Hartmann 1962.

Remarks. The species here assigned with query to *Patagonacythere* differs in details of muscle scar pattern both from the type species described by Hartmann and from the two species described by Benson (1964) from the Antarctic. In common with the described species it shows the three longitudinal ridges in which a characteristic posterodorsal loop joins the upper two.

Patagonacythere ? nidulus sp. nov.

(Plate 28, figs. 5–12 ; Plate 29, figs. 1–4)

Derivation of name. Latin *nidulus*, small bird's nest ; with reference to the reticulate complex of the subcentral node.

Diagnosis. Carapace highly reticulate in which ventral ridge culminates abruptly in posterior third, subcentral-tubercle prominent.

Holotype. Io. 4349, a female carapace (Pl. 28, figs. 9–12).

Paratypes. Io. 4295 + Io. 3096–8.

Material. Over 400 specimens from the Zao River section from 16 horizons (sample nos. 24155 to 24157, 24159, 24166, 24170, 24173, 24175 to 24178, 24180, 24183, 24185, 24187 and 24193). Approximately 60 specimens from the Rakhi Nala section from 13 horizons (sample nos. 3624, 3625, 3628, 3631, 3634, 3640 to 3642, 3645, 3646, 3649, 3658 and 3662). GSP BM 2568–9.

TYPE LOCALITY. Zao River section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 24173.

DESCRIPTION. *Carapace* subrectangular in side view with dorsal and ventral margins almost straight, subparallel ; anterior broadly rounded, posterodorsal margin very slightly concave (particularly in the right valve), posterior extremity and posteroventral margin rounded. Anterior cardinal angle well-developed in both valves ; posterior cardinal angle in the left valve obtuse and well-marked but in the right valve it is not very well developed. Left valve over-reaches the right valve slightly at the anterior cardinal angle and at the posterodorsal slope, otherwise the two valves are equal in size. In the dorsal view the greatest width passes either through the subcentral-tubercle or through the posterior third with a sulcus in between. *Eye-tubercle* rounded, polished and distinct ; *subcentral-tubercle* prominent, composed of reticulate complex. Shell surface strongly reticulate with three longitudinal ridges : the ventral ridge slopes obliquely upward towards the posterior, ending abruptly just before reaching the compressed posterior platform; the median ridge springs from the subcentral node, stretching backward to join the ventral ridge and forms a posterodorsal loop. (In some specimens at certain horizons longitudinal ridges are not well-developed.) A marginal rim runs round the anterior, ventral and posterior margins—it is upraised around the anterior margin. Anterior margin ornamented with approximately 20 small spines, posterior margin with 6–8 spines. *Normal pore canals* fairly numerous (these become exaggerated in specimens cleaned in ultrasonic vibrator). *Radial pore canals* simple, nearly straight, irregularly spaced ; few cross one another. There are approximately 40 anterior radial pore canals and about 20 posterior canals. *Inner margin* and *line of concrescence* coincide. *Duplicature* of moderate width (0·073 mm. at anterior, 0·06 mm. at posterior extremity). *Selvage* prominent, submarginal in left valve, at some distance from the margin in the right valve. *Flange groove* well-developed (particularly in the right valve) on the venter and around the anterior margin. *Adductor muscle scars* are in a vertical column of four elongate scars, the second from the top being longest and the bottom one the shortest. There are two frontal scars, the top one is smaller and almost rounded, but the bottom one is ovate. *Hinge* holamphidont :

Element	Left valve	Right valve
Anterior	Deep socket bounded on venter, confluent with ocular sinus.	Strongly projecting slightly stirpate tooth with a concavity on anterior in dorsal view. Ocular sinus opens below and slightly anterior to it.
Anteromedian	Conical tooth with straight anterior and convex posterior in dorsal outline.	Deep rounded socket.

Element	Left valve	Right valve
Posteromedian	Denticulate bar.	Locellate groove.
Posterior	Deep socket bounded on venter.	Tooth which in dorsal view appears pessular but in reality is semicircular or slightly trilobate. In oblique view it can be seen that the line of concrescence deviates in the neighbourhood of the posterior tooth so that only the outside of the semi-circular tooth is bilamellar thus enclosing a monolamellar core formed by the invagination of the line of concrescence.

DIMENSIONS (mm).

		L	H	W
Io. 3096	Carapace male	0·80	0·44	0·41
Io. 4349	Carapace female (holotype)	0·74	0·44	0·39
Io. 3097	Left valve female	0·75	0·45	—
Io. 3098	Right valve female	0·76	0·44	—
Io. 4295	Right valve male	0·80	0·45	—

COMPARISON. The presence of a reduced ventral ridge, which does not reach the posterior marginal rim, separates this species from *Patagonacythere tricostata* Hartmann, *Patagonacythere devexa* (Müller) and *Patagonacythere longiducta antarctica* Benson. *Patagonacythere tricostata* Hartmann (1962) has a smaller and more elongate carapace and three rather than two frontal scars. *Patagonacythere devexa* (Müller) Benson (1964) is larger, has narrow anterior and posterior vestibules, split adductor scars and ill-defined median and dorsal ridges including the posterodorsal loop. (Comparative material of this species from the British Antarctic region was obtained through the courtesy of Dr. R. C. Whately of Aberystwyth.) *Patagonacythere longiducta antarctica* Benson (1964) is about the same size, has a more concave posterodorsal slope and the two median adductor scars are split.

REMARKS. The present species commonly occurs in the Zao River and Rakhi Nala sections, where it has a short vertical range. It is thus a very useful species for correlation in this region. *Patagonacythere* has so far only been described from cold water regions, but *P ? indulus* occurs here in a warm water environment. A new generic assignment will therefore probably be necessary at a later time.

Genus ***PHALCOCYTHERE*** nov.

DERIVATION OF NAME. Greek *phalkes*, beam or rib of a ship ; with reference to the ventral ridge + *cythere*.

Diagnosis. Reticulate Trachyleberididae with a ventral ridge ; with or without spines or papillae ; mostly with pronounced posterodorsal process.

Type species. *Cythere horrescens* Bosquet 1852.

Description. Sexual dimorphism present in most of the species. Carapace subrectangular to subquadrate in lateral outline. Anterior margin broadly rounded, posterodorsal margin very slightly concave, posterodorsal margin either curved or almost straight, dorsal margin almost straight or slightly convex (but appears irregular in lateral outline in many species due to surface ornamentation), ventral margin slightly concave in front of the middle or nearly straight (over-reached by a ventral ridge in lateral view in some species). Valves almost equal in size although the right valve over-reaches the left at the anterior margin. Subcentral-tubercle more or less well-developed. Eye-tubercle distinct. Surface reticulate with or without superimposed papillae or spines. A posterodorsal process is generally present. A ventral ridge more or less prominent is always present ; it is either straight or slightly curved convexly downward in the middle culminating in the posterior fourth usually in a spine or an ala. Anterior and posterior marginal rims always present, more or less distinct. Radial pore canals simple, almost straight, irregularly spaced, sometimes crossing one another, fairly numerous (approximately 30 anteriorly in the type species). Line of concrescence and inner margin coincide. Duplicature fairly wide. Selvage more or less pronounced, submarginal in left valve but at some distance in the right valve. Right valve with a deep and well-developed anterior and ventral flange groove. Adductor scars in a vertical column of four elongate scars with two almost rounded frontal scars (see description of *P. horrescens*). Hinge holamphidont.

Comparison. *Hirsutocythere* Howe 1951 has a wider duplicature and lacks a ventral ridge. *Australicythere* Benson 1964 is a much larger genus in which fine pittings occur within the reticulae. The two median adductor scars are also divided into two. Moreover, *Australicythere* has a posterior vertical ridge and a less prominent ventral ridge not ending in a spine posteriorly. *Bradleya* Hornibrook 1952 has both dorsal and ventral ridges, in this respect it differs from *Phalcocythere* which has only a ventral ridge.

Remarks. This genus is so far known from the Eocene of the Paris Basin, West Pakistan, Tanzania and an undescribed species from the Aquitaine Basin.

Phalcocythere horrescens (Bosquet)

(Plate 29, fig. 5 ; Plate 30, figs. 1–6 ; Plate 33, figs. 12, 13)

1852 *Cythere horrescens* Bosquet, p. 119, pl. 6, fig. 5.
1852 *Cythere thierensiana* Bosquet (pars), p. 98.
1852 *Cythere nebulosa* Bosquet, p. 105, pl. 5. fig. 8.
1955 *Trachyleberis horrescens* (Bosquet), Apostolescu, p. 272, pl. 8, figs.125–126.
1957 *Hirsutocythere horrescens* (Bosquet), Keij, p. 101, pl. 15, fig. 4 ; pl. 17, figs.6–7.

Diagnosis. *Phalcocythere* in which posteroventral margin is straight in left valve but curved in the right with five or six large spines, shell surface ornamented by well-

developed spines superimposed on reticulations ; ventral ridge and posterodorsal process well-marked.

FIGURED SPECIMENS. Io. 4253–7.

MATERIAL. 8 specimens from Grignon, Paris Basin, from the Lutetian IV (sample no. CAB 1002, Keij 1957, p. 19). 5 specimens from Villiers-St.-Frederic, Paris Basin, from the same horizon.

TYPE LOCALITY. Grignon, Paris Basin.

TYPE HORIZON. Lutetian.

DIMENSIONS (mm).

		L	H
Io. 4253	Left valve	0·60	0·33
Io. 4257	Left valve	0·59	0·33
Io. 4254	Left valve	0·72	0·37
Io. 4255	Right valve	0·59	0·33
Io. 4256	Right valve	0·63	0·37

COMPARISON. This species shows some affinity to *Phalcocythere retispinata* sp. nov. but has a more spinose surface, less tapering carapace and a better developed subcentral-tubercle. Further, *P. horrescens* has straight posteroventral margin in the right valve, different posterodorsal process and less prominent eye-tubercle which lies below and slightly posterior to the anterior cardinal angle.

REMARKS. The present species has been redescribed by Keij (1957) in detail, where, although he ascribed it to the genus *Hirsutocythere*, he noted that it lacked the very wide duplicature of that genus.

Adult specimens vary in size. According to Apostolescu (1955, p. 272), they range from 0·52 mm. to 0·70 mm. in length.

Phalcocythere improcera sp. nov.

(Plate 30, figs. 7–12 ; Plate 31, figs. 1–4)

DERIVATION OF NAME. Latin, *improcerus*, short ; with reference to the carapace.

DIAGNOSIS. A small *Phalcocythere* in which the prominent ventral ridge possesses an alar expansion ; posteroventral margin slightly protracted towards the venter, subcentral-tubercle prominent.

HOLOTYPE. Io. 4344, a male carapace (Pl. 31, figs. 1, 2 ; Pl. 30, figs. 8, 9).

PARATYPES. Io. 4296 + Io. 4258–9.

MATERIAL. 68 specimens from the Sor Range section from four horizons (sample nos. 460-i, 460-j, 460-l and 460-n). GSP BM 2570–1.

TYPE LOCALITY. Sor Range section.

TYPE HORIZON. Upper Palaeocene, sample no. 460-i.

DESCRIPTION. *Carapace* subrectangular in the male dimorph and sub-quadrate in the female. Sexual dimorphy is rather marked ; the males are longer in proportion

than the females. Anterior margin broadly rounded, posterodorsal margin very slightly concave, posteroventral margin rounded and slightly protracted towards the venter. Dorsal margin straight but appears irregular in lateral view because of the surface ornamentation ; ventral margin nearly straight (concealed in side view by the ventral ridge). Anterior and posterior cardinal angles well-developed in the right valve but more or less rounded in the left valve. Right valve slightly over-reaches the left at the anterior margin but the left valve over-reaches the right in the region of the posterodorsal slope. *Subcentral-tubercle* prominent. *Eye-tubercle* distinct, rounded and glassy. Shell surface deeply reticulate with superimposed papillae or spines, the ornamentation extending onto the prominent ventral ridge (over-reaching the ventral margin in lateral view) which also develops an alar expansion. The posterodorsal process is developed as a short curved horn-like ridge in specimens with papillose ornamentation but is a projecting, blade-like process in specimens having a spinose surface. Anterior and posterior marginal rims distinct. Anterior margin finely denticulate with 20–22 denticles, posteroventral margin with 7–8 short spines. *Normal pore canals* fairly numerous, one to each reticule. (These become exaggerated in specimens cleaned in the ultrasonic vibrator). *Radial pore canals* not very well preserved but appear to be simple, more or less straight, irregularly spaced, some crossing one another, approximately 35 anteriorly. *Line of concrescence* and *inner margin* coincide. *Duplicature* moderately wide. *Selvage* prominent—submarginal in the left valve but situated in the outer two-fifths of the duplicature in right valve which also has a deep and well marked anterior and ventral *flange groove*. *Hinge* not clearly seen but appears to be holamphidont.

Dimensions (mm).

		L	H	W
Io. 4344	Carapace male (holotype)	0·49	0·29	0·27
Io. 4258	Carapace female	0·49	0·30	0·29
Io. 4295	Left valve female	0·46	0·28	—
Io. 4296	Right valve female	0·46	0·27	—

Comparison. Distinguished from the other known species of the genus *Phalcocythere* by its small size and the posteroventral margin slightly drawn out towards the venter particularly in the right valve.

Remarks. The surface ornamentation is variable. Most of the specimens examined have a combination of reticulations and papillae but in a few specimens spines are superimposed on reticulations.

Phalcocythere rete sp. nov.

(Plate 31, figs. 5–12)

Derivation of name. Latin *rete*, net ; with reference to the surface ornamentation.

Diagnosis. Reticulate *Phalcocythere* in which eye-tubercle is prominent, ventral ridge present but not prominent, dorsal margin slightly convex particularly in female.

HOLOTYPE. Io. 4348, a female right valve (Pl. 31, figs. 11).

PARATYPES. Io. 4297 + Io. 3099 + Io. 3141.

MATERIAL. 14 specimens including the holotype from the Sor Range section from one horizon (sample no. 460-i). GSP BM 2572–3.

TYPE LOCALITY. Sor Range section.

TYPE HORIZON. Upper Palaeocene, sample no. 460-i.

DESCRIPTION. Sexual dimorphy rather strong ; the males are longer, less high and less wide than the females. *Carapace* subrectangular to subquadrate in lateral view with a slight taper towards the posterior. Dorsal margin slightly convex particularly in the female, ventral margin almost straight, anterior broadly and evenly rounded, posterodorsal slope very slightly concave, posteroventral margin rounded. Left valve slightly over-reaches the right at the anterior margin. *Subcentral-tubercle* distinct, *eye-tubercle* prominent, rounded and polished. Shell surface reticulate, the reticulae are slightly papillose. The ventral ridge is present but not prominent, sloping obliquely upward towards the posterior and culminating in the posterior third. Marginal rim distinct. Anterior and posterior margins denticulate. *Radial pore canals* simple, straight, slightly thicker on the proximal end, irregularly spaced, about 30 anteriorly. *Inner margin* and *line of concresence* coincide. *Duplicature* fairly wide, 0·060 mm. anteroventrally. *Selvage* well-developed—submarginal in left valve but almost in the middle in the right valve. There is a deep anterior and ventral *flange* groove in the right valve. *Hinge* not clearly distinguished due to mineralization but presumably holamphidont.

DIMENSIONS (mm).

		L	H	W
Io. 3099	Carapace male	0·65	0·35	0·24
Io. 4297	Carapace female	0·47	0·35	0·27
Io. 3141	Left valve female	0·46	0·35	—
Io. 4348	Right valve female (holotype)	0·46	0·35	—

COMPARISON. *Phalcocythere retispinata* sp. nov. is a closely related species but has a reticulate and spinose surface, a more elevated ventral ridge and a well-developed posterodorsal process.

Phalcocythere retispinata sp. nov.

(Plate 31, figs. 13–17 ; Plate 32, figs. 1–3)

DERIVATION OF NAME. Latin *rete*, net + *spinatus*, spined ; with reference to the surface ornamentation.

DIAGNOSIS. *Phalcocythere* with a prominent ventral ridge with alar expansion, surface ornamentation a combination of reticulations and spines, subcentral-tubercle present but not pronounced, eye-tubercle prominent, posterodorsal process well-marked.

HOLOTYPE. Io. 4345, a female carapace (Pl. 31, figs. 15, 16 ; Pl. 32, figs. 2, 3).

PARATYPE. Io. 3165.

Material. Six specimens from the below locality from three horizons (sample nos. 460-i, 460-j and 460-o). GSP BM 2574.

Type locality. Sor Range section.

Type horizon. Upper Palaeocene, sample no. 460-i.

Description. Sexual dimorphism rather pronounced ; the females are higher and wider than the males. *Carapace* tapering towards the posterior, subrectangular in side view. Dorsal margin nearly straight in the male dimorph but very slightly convex in the female (appears to be irregular in dorsal view due to ornamentation) ; ventral margin almost straight but concealed by the ventral ridge in side view ; anterior broadly rounded, posterodorsal margin very slightly concave ; posteroventral margin rounded. Greatest length lies below mid-point, greatest height in the anterior third. Anterior and posterior cardinal angles well-developed. Right valve very slightly over-reaches the left at the anterior margin. *Subcentral-tubercle* present but not pronounced. *Eye-tubercle* prominent, rounded and polished. Ornamentation consists of reticulations and spines. The spines are of variable size. A posterodorsal process consists usually of a large spine, which stands out in lateral view. The ventral ridge is high and with an alar expansion, slightly concave in the middle culminating in the posterior third with a pointed end. Anterior and posterior marginal rims more or less distinct and decorated with a row of spines. Anterior and posterior margins denticulate. Internal characters not seen.

Dimensions (mm).

		L	H	W
Io. 3165	Carapace male	0·64	0·37	0·27
Io. 4345	Carapace female (holotype)	0·64	0·39	0·32

Comparison. *Phalcocythere improcera* sp. nov. is much smaller, has deeper reticulations and a posteroventral margin slightly drawn out towards the venter.

Phalcocythere sentosa sp. nov.

(Plate 32, figs. 4–10)

Derivation of name. Latin *sentosus*, rough ; with reference to the surface ornamentation.

Diagnosis. A species of the genus *Phalcocythere* in which ventral ridge is present but not high ; surface ornamentation consists of combination of reticulations and papillae ; posterodorsal process a small tubercle or short spine. Subcentral-tubercle distinct, eye-tubercle prominent.

Holotype. Io. 4346, a male carapace (Pl. 32, figs. 4, 5, 8, 10).

Paratype. Io. 4298.

Material. 67 specimens from the Rakhi Nala section from 11 horizons (sample nos. 3153, 3165, 3167, 3169, 3170, 3173 to 3177 and 3180). GSP BM 2575–6.

Type locality. Rakhi Nala section.

Type horizon. Upper Rakhi Gaj Shales, sample no. 3167.

DESCRIPTION. Strongly dimorphic, the females are less elongate than the males. *Carapace* subrectangular in lateral view. Anterior broadly rounded, posterodorsal slope very slightly concave, posteroventral margin rounded, dorsal margin almost straight, appearing irregular in lateral view, ventral margin slightly concave anterior to the middle. Right valve slightly over-reaches left valve at the anterior margin but is over-reached by the latter in the region of the posterodorsal slope. Anterior and posterior cardinal angles well-developed, particularly in the right valve. *Eye-tubercle* rounded and prominent, projecting out from the eye-socket. *Subcentral-tubercle* distinct. Surface reticulate with superimposed papillae, posterodorsal process either a small more or less rounded tubercle or a cluster of short spines ; ventral ridge present but not elevated. Anterior and posterior marginal rims distinct. Anterior margin denticulate, posteroventral margin papillose. Internal details not observed.

DIMENSIONS (mm).

		L	H	W
Io. 4346	Carapace male (holotype)	0·56	0·32	0·25
Io. 4298	Carapace female	0·55	0·32	0·29

COMPARISON. *Phalcocythere rete* sp. nov. is larger than the present species, has a less papillose surface and slightly convex dorsal margin in the female.

REMARKS. So far only known from the Rakhi Nala section. The posterodorsal process varies; in some specimens it is almost a rounded tubercle but in others it is a short spine.

Phalcocythere dissenta sp. nov.

(Plate 32, figs. 11–18)

DERIVATION OF NAME. Latin *dis*, not + *sentus*, spiny.

DIAGNOSIS. A reticulate species of the genus *Phalcocythere* with dorsal and ventral margins sub-parallel, anterior rim ornamented like a scallop or flute, subcentral-tubercle prominent, eye-tubercle and ventral ridge distinct.

HOLOTYPE. Io. 4343, a male carapace (Pl. 32, figs. 11, 14, 18).

PARATYPE. Io. 4299.

MATERIAL. Approximately 400 specimens from the locality above from six horizons (sample nos. 3454, 3456, 3460 to 3462 and 3464) and 6 specimens from the Zao River section from one horizon (sample no. 24107). GSP BM 2577–8.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Shales with Alabaster, sample no. 3456.

DESCRIPTION. Sexual dimorphism marked, the presumed males are more elongate, less high and less wide than the females. *Carapace* sub-rectangular in lateral outline with sub-parallel dorsal and ventral margins. Anterior margin broadly rounded ; posterodorsal slope more or less straight ; posteroventral margin rounded ; dorsal margin slightly convex particularly in the female ; ventral margin almost straight, although partly hidden by the ventral ridge in lateral view. Greatest

length passes through mid-point, greatest height in the anterior third and greatest width in the anterior two-fifths. Anterior and posterior cardinal angles protruding. Valves almost equal. *Subcentral-tubercle* prominent, *eye-tubercle* distinct and situated below the cardinal angle. Anterior marginal rim distinct, and ornamented with seven very short ridges with small depressions in between (like flutes or scallops), posterior rim more or less distinct. Surface reticulate with a distinct ventral ridge which slopes obliquely upwards posteriorly ending in the posterior third. In many specimens the posterior ending is pointed or spinose. Internal details not determinable, all specimens being complete carapaces.

Dimensions (mm).

		L	H	W
Io. 4343	Carapace male (holotype)	0·60	0·44	0·32
Io. 4299	Carapace female	0·56	0·44	0·44

Comparison. This species shows some resemblance to *Phalcocythere rete* sp. nov. but is smaller and has subparallel rather than tapering dorsal and ventral margins. It differs from *Phalcocythere improcera* sp. nov. and *Phalcocythere sentosa* sp. nov. in shape and surface ornamentation.

Remarks. *P. dissenta* seems to be restricted to the Shales with Alabaster only and has been found in the Rakhi Nala and Zao River sections. It is abundant in the Rakhi Nala section but rare in the Zao River area.

Phalcocythere spinosa sp. nov.

(Plate 33, figs. 1, 2, 7, 8)

Derivation of name. Latin *spinosus*, spiny.

Diagnosis. A species belonging to the genus *Phalcocythere* with short spines and/or papillae superimposed on reticulations ; ventral ridge distinct and terminating in a spine in posterior third ; posterodorsal process well-marked and blade-like.

Holotype. Io. 4347, a carapace.

Material. 16 specimens from the Zao River section from one horizon (sample no. 24161). GSP BM 2579.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24161.

Description. *Carapace* subrectangular in side view. Dorsal margin almost straight, appearing to be irregular in lateral view due to ornamentation ; ventral margin more or less straight but hidden by the ventral ridge in side view ; anterior margin broadly rounded ; posterodorsal margin slightly concave ; posteroventral margin rounded. Greatest length passes through the mid-point and greatest height passes through the anterior cardinal angle. Valves nearly equal. *Subcentral-tubercle* well-developed, *eye-tubercle* rounded, distinct and lies below the anterior cardinal angle. Surface ornamentation consists of short spines and/or papillae superimposed on reticulations. A distinct ventral ridge, diagnostic of the genus,

over-reaches the ventral margin in lateral view and is spinose posteriorly. It extends from the anteroventral corner to the posterior third. The posterodorsal process is projecting and blade-like (present in most specimens). Anterior and posterior marginal rims distinct. Anterior margin finely denticulate, posteroventral margin ornamented with 6–7 short spines or papillae. Internal features not seen.

Dimensions (mm).

		L	H	W
Io. 4347	Carapace (holotype)	0·54	0·33	0·44

Comparison. *Phalcocythere sentosa* sp. nov. is similar and perhaps ancestral to the present species. These two, however, can be separated easily due to the fact that *P. sentosa* is strongly dimorphic and has a less well-developed ventral ridge and a posterodorsal process.

Remarks. This species has so far only been recorded from one horizon of the Upper Chocolate Clays of the Zao River section. Sexual dimorphism has not been observed in this species.

Phalcocythere sp., cf. ***P. spinosa***

(Plate 33, figs. 3–6, 9–11)

Figured specimens. Io. 4230—Io. 4232.

Material. Five specimens from the locality and horizon below (other specimens in the collections of the British Petroleum Co. Ltd., under registration no. FCRM 1648). GSP BM 2580.

Locality. Lindi survey, 10–50 ft. above shore at Kitunga, Tanzania.

Horizon. Upper Eocene.

Description. Sexual dimorphism rather marked ; the females are higher and wider than the males. *Carapace* subrectangular to subquadrate in lateral outline. Dorsal margin irregular in lateral view due to ornamentation ; ventral margin almost straight ; anterior margin broadly rounded ; posterodorsal margin very slightly concave ; posterior extremity rounded. Right valve over-reaches the left slightly at the anterior margin. Anterior and posterior cardinal angles well-developed particularly in right valve. Greatest length below mid-point, greatest height at anterior cardinal angle and greatest width in the posterior third. *Subcentral-tubercle* distinct. *Eye-tubercle* rounded and prominent. Anterior and posterior marginal rims distinct. Surface ornamentation consists of reticulations with superimposed spines ; ventral ridge prominent, posteriorly alate, ending abruptly in the posterior third ; posterodorsal process prominent and blade-like, standing out in lateral and dorsal views. Anterior margin ornamented with numerous very short spines ; posterior with six larger spines. *Radial pore canals* not discernible. *Duplicature* moderately wide. *Selvage* strong—marginal in left valve but in right valve it is in the outer third. Right valve with a deep *flange groove*. *Muscle scars* are in a vertical row of four adductors, and frontal scars not seen. *Hinge* holamphidont with the details of each element as follows:

Element	Left valve	Right valve
Anterior	Deep rounded socket.	Projecting conical tooth. Eye-socket opens below and slightly anterior to this tooth.
Anteromedian	Conical projecting tooth.	Socket opening into groove.
Posteromedian	Denticulate bar.	Shallow locellate groove narrowing towards posterior.
Posterior	Elongate groove, presumably deep (filled in with matrix).	Subpessular tooth, higher on the posterior side.

Dimensions (mm).

		L	H	W
Io. 4230	Carapace male	0·55	0·32	0·30
Io. 4231	Carapace female	0·56	0·34	0·34
Io. 4232	Right valve female (broken)—½w, 0·17			

Comparison. *Phalcocythere spinosa* sp. nov. closely approaches the present form but is smaller, has a less reticulate and spinose surface and a more concave postero-dorsal slope. *Phalcocythere retispinata* sp. nov. is much larger, has a slightly convex dorsal margin particularly in the female dimorph, and the carapace tapers towards the posterior.

Remarks. The specimens studied were made available through the kindness of Dr. F. E. Eames, lately Chief Palaeontologist of the British Petroleum Co. Ltd. These specimens may represent a distinct sub-species of *P. spinosa*.

Genus *QUADRACYTHERE* Hornibrook 1952

Type species. *Cythere truncula* Brady 1898.

Subgenus *HORNIBROOKELLA* Moos 1965

Type species. *Cythere anna* Lienenklaus 1894.

Quadracythere (Hornibrookella) platybomus sp. nov.

(Plate 33, figs. 14, 15, 18, 19).

Derivation of name. Greek *platys*, broad + *bomos*, bottom ; with reference to the expanded venter.

Diagnosis. Carapace with expanded venter, subrectangular to subquadrate in lateral outline.

Holotype. Io. 4351, a male carapace (Pl. 33, figs. 14, 18).

Paratype. Io. 4300.

Material. Nine specimens from the locality below from two horizons (sample nos. 460-i and 460-o). GSP BM 2581–2.

TYPE LOCALITY. Sor Range section.

TYPE HORIZON. Upper Palaeocene, sample no. 460-i.

DESCRIPTION. *Carapace* subrectangular in the male dimorph and subquadrate in the female. Sexual dimorphism rather apparent ; the females are higher and wider than the males. Carapace compressed in the posterior region. Anterior margin broadly rounded, posterodorsal slope very slightly curved, posterior almost rounded, posteroventral margin slightly curved. The ornamentation over-reaches the dorsal margin giving a jagged appearance, ventral margin almost straight in the male but slightly curved in the female. Left valve very slightly over-reaches the right at the posterodorsal slope and at the anterior cardinal angle. In dorsal view the greatest width is situated anterior to the middle. *Subcentral-tubercle* prominent, *eye-tubercle* distinct. A marginal rim runs around the anterior, ventral and posterior margins. It is upraised around the anterior but less elevated along the venter and around the posterior end. Surface reticulate with a well-marked ventral ridge giving rise to an expanded venter. At the posterodorsal corner a small horn-like projecting ridge is present. Anterior margin ornamented by small, numerous denticles (20–25 in number) but the posterior has only a few denticles.

DIMENSIONS (mm).

		L	H	W
Io. 4351	Carapace male (holotype)	0·57	0·32	0·24
Io. 4300	Carapace female	0·57	0·34	0·29

COMPARISON. *Quadracythere* (*Hornibrookella*) *directa* sp. nov. is larger, has a less well-developed subcentral-tubercle and lacks an expanded venter.

REMARKS. The preservation of the material prevents a description of the internal characters. So far this species is only known from the Upper Palaeocene of the Sor Range section.

Quadracythere (Hornibrookella) directa sp. nov.

(Plate 33, figs. 16, 17 ; Plate 34, figs. 1, 2)

DERIVATION OF NAME. Latin *directus*, rectangular ; with reference to the outline in lateral view.

DIAGNOSIS. In lateral view carapace subrectangular with protruding anterior and posterior cardinal angles. Surface ornamentation consists of reticulation with an oblique ventral ridge sloping upward towards posterior and a short horn-like ridge at posterodorsal corner. Sexual dimorphism pronounced.

HOLOTYPE. Io. 4350, a female carapace (Pl. 33, figs. 17 ; Pl. 34, fig.2).

PARATYPE. Io. 4301.

MATERIAL. 96 specimens from the type locality from four horizons (sample nos. 3184, 3192, 3402 and 3403). GSP BM 2583–4.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Green and Nodular Shales, sample no. 3403.

Description. Sexual dimorphy rather apparent ; the females are shorter, higher and wider than the males. *Carapace* subrectangular in side view with the greatest height at the anterior cardinal angle and the greatest length below the middle. Anterior margin broadly and evenly rounded, posterodorsal slope very slightly concave, posterior extremity subtriangular, posteroventral margin almost straight. Dorsal margin very slightly undulating, venter slightly incurved in front of the middle. Posterior portion of carapace compressed. Anterior marginal rim high continuing along the venter and around the posterior end as a somewhat less elevated rim. Anterior margin set with numerous small and delicate denticles, posterior with a few denticles. Anterior and posterior cardinal angles protruding. Left valve overreaches the right valve slightly at the anterior cardinal angle and posterodorsal slope. In dorsal view the greatest width is situated almost in the middle of the carapace. *Eye-tubercle* distinct. *Subcentral-tubercle* more or less distinct. Surface reticulate with a ventral ridge, which slopes slightly upwards towards the posterior. A short curved, hornlike ridge at the posterodorsal corner is present (better seen in dorsal view). Internal details not known.

Dimensions (mm).

		L	H	W
Io. 4301	Carapace male	0·68	0·35	0·27
Io. 4350	Carapace female (holotype)	0·63	0·37	0·29

Comparison. *Quadracythere* (*Hornibrookella*) *subquadra* sp. nov. is subquadrate in lateral outline, has deeper reticulations and a better developed subcentral-tubercle.

Quadracythere (Hornibrookella) arcana (Lubimova and Guha)

(Plate 34, figs. 3–5)

1960 *Cythereis arcanus* (sic., recte *Cythereis arcana*) Lubimova and Guha, p. 33, pl. 3, fig. 1a–b.

Diagnosis. Carapace with distinct caudal process. Surface coarsely reticulate with superimposed longitudinal lineations in posterior half of carapace.

Figured specimen. Io. 3142.

Material. Two specimens from the locality and horizon below.

Locality. Rakhi Nala section.

Horizon. Lower Chocolate Clays, sample no. 3499.

Description. *Carapace* thick-shelled, subquadrate in lateral view. Anterior margin broadly rounded, posterior with a pronounced caudal process. Dorsal margin slightly concave behind the round and protruding anterior cardinal angle, particularly in the right valve. Ventral margin almost straight. Greatest height at the anterior cardinal angle and greatest length below the middle. Left valve slightly overreaches the right in the region of the anterior cardinal angle and posterodorsal slope. *Eye-tubercle* rounded and distinct, *subcentral-tubercle* well-developed. Surface ornamentation consists of coarse reticulations with superimposed longitudinal lineations in the posterior half of the carapace. The ventral ridge is slightly concave downwards culminating in an ala posteriorly. A short ridge at the posterodorsal

corner meets the dorsal margin at an angle (better seen in dorsal view) and ends as an ala at the posterior. A marginal rim runs round the anterior, along the venter and round the posterior margin.

Dimensions (mm).

		L	H	W
Io. 3142	Carapace	0·54	0·32	0·32

Remarks. Topotype material was not available for study, and it is, therefore, difficult to determine whether or not the Rakhi Nala specimens are conspecific with those from the type locality in Kutch.

Quadracythere (Hornibrookella) subquadra sp. nov.

(Plate 34, figs. 6–11)

Derivation of name. Latin *subquadrus*, almost square ; with reference to the outline in lateral view.

Diagnosis. Carapace subquadrate with dorsal and ventral margins almost straight and subparallel. Surface strongly and coarsely reticulate. Sexual dimorphy moderate.

Holotype. Io. 4352, a female carapace (Pl. 34, figs, 7, 10, 11).

Paratype. Io. 4302.

Material. 41 specimens from the locality below from one horizon (sample no. 24161). GSP BM 2585–6.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24161.

Description. *Carapace* subquadrate in lateral outline with a short caudal process. Anterior margin broadly rounded, posterodorsal slope slightly concave, posterior extremity almost straight, posteroventral margin curved. Dorsal and ventral margins nearly straight and sub-parallel. Greatest height at the anterior cardinal angle, greatest length below the mid-point. In dorsal view the greatest width is situated in front of the middle. Anterior cardinal angle rounded, posterior cardinal angle well-developed. Left valve over-reaches the right valve slightly in the region of the posterodorsal slope and the anterior cardinal angle. *Subcentral-tubercle* prominent, *eye-tubercle* rounded and distinct. Surface coarsely and deeply reticulate. There is a distinct ventral ridge at some distance from the venter and a short curved hornlike ridge at the posterodorsal corner. Anterior marginal rim prominent continuing along the venter and around the posterior margin as a less prominent rim. Anterior margin ornamented with numerous denticles.

Sexual dimorphism moderate ; the presumed females are wider than the males.

Dimensions (mm).

		L	H	W
Io. 4302	Carapace male	0·66	0·40	0·32
Io. 4352	Carapace female (holotype)	0·67	0·42	0·34

Comparison. *Quadracythere* (*Hornibrookella*) *arcana* (1960) is smaller, has a well-developed caudal process, superimposed longitudinal lineations and a ventral ridge slightly curved downward. *Quadracythere* (*Hornibrookella*) *platybomus* sp. nov. is also smaller, has a different lateral outline, less deep reticulations and an expanded venter.

Remarks. *Quadracythere* (*Hornibrookella*) *subquadra* sp. nov. commonly occurs at one horizon (sample no. 24161) of the Upper Chocolate Clays in the Zao River section associated with *Echinocythereis multibullata* sp. nov. and *Phalcocythere spinosa* sp. nov.

Quadracythere (Hornibrookella) sp.A

(Plate 34, figs. 12–14)

Figured specimen. Io. 3143.

Material. Only one specimen from the locality and horizon below.

Locality. Zao River section.

Horizon. Upper Chocolate Clays, sample no. 24148.

Description. *Carapace* subquadrate in side view. Dorsal and ventral margins almost straight, anterior margin broadly and obliquely rounded, posterodorsal margin slightly concave, posteroventral margin rounded. Greatest length lies below the middle, greatest height at the anterior cardinal angle. In dorsal view the greatest width lies anterior to the middle. Valves almost equal. *Eye-tubercle* distinct, rounded. *Subcentral-tubercle* distinct. Surface coarsely and deeply reticulate. Reticulae are somewhat concentrically arranged around the subcentral-tubercle. Dorsal ridge present but not well-defined, ventral ridge more or less distinct. A low marginal rim runs around the anterior and posterior margins. Anterior and posteroventral margins denticulate. Internal characters not observed.

Dimensions (mm).

		L	H	W
Io. 3143	Carapace	0·93	0·54	0·56

Comparison. This is similar to *Quadracythere* (*Hornibrookella*) *subquadra* sp. nov. but is much larger, has coarser and deeper reticulations more or less arranged in a concentric pattern around the subcentral-tubercle. In addition, these two species differ markedly in their posterior outline.

Genus *STIGMATOCYTHERE* nov.

Derivation of name. Greek *stigma*, mark ; with reference to the ornamentation +*cythere*.

Diagnosis. Highly ornamented Trachyleberididae in which two ridges spring from the eye-tubercle, one to form a high anterior marginal rim, the other curving sharply round to join the subcentral-tubercle.

Type species. *Stigmatocythere obliqua* sp. nov.

DESCRIPTION. Carapace subrectangular in lateral outline. Sexual dimorphy apparent ; the males are longer, less high and less wide than the females. Left valve slightly over-reaches the right in the region of the anterior cardinal angle and at the posterodorsal slope. Subcentral node and eye-tubercle distinct. Surface reticulate, spiny, or a combination of reticulations and spines or with only one to three longitudinal ridges or lines of ornamentation. The dorsal ridge or line when developed may be straight or arched convexly upwards. A strongly curved ridge, diagnostic of the genus, runs from the eye-tubercle to the anterodorsal corner of the subcentral complex and this may be continued posteriorly either as a ridge or a line of tubercles. The anterior marginal rim also springs from the eye-tubercle and is more or less elevated in the anterior region, continuing as a less elevated rim round the venter and posterior margins. A ventral ridge or line of tubercles diverges posteriorly from the ventral marginal rim. Anterior and posterior margins spinose. Normal pore canals simple, medium, some 60 in the female left valve. Radial pore canals simple, straight, irregularly spaced, some crossing one another, 24–26 anteriorly. Inner margin and line of concrescence coincide. Anterior duplicature moderately wide. Selvage well-marked in both valves, submarginal in the left valve but almost in the outer third of the duplicature in right valve. In right valve a well-developed flange groove is present along the ventral margin and around the anterior margin. Muscle scars consist of four adductor scars in an almost vertical column with an oval frontal scar. Hinge holamphidont ; right valve hinge with a strongly projecting anterior tooth followed by anteromedian socket, posteromedian locellate groove present or reduced to a narrow shelf, a posterior tooth, projecting reniform or pessular. Left valve hinge with anterior and posterior sockets, a conical anteromedian tooth and a posteromedian denticulate or almost smooth bar.

COMPARISON. *Stigmatocythere* differs from the genus *Gyrocythere* in the arrangement of the longitudinal ridges and by having a strongly curved ridge connecting the eye-tubercle and the subcentral-tubercle. The anterior marginal rim is less evident in *Gyrocythere* while it is well developed in *Stigmatocythere*. *Costa* has three or four continuous longitudinal ridges, the median or second of which has a characteristic posterior termination absent in *Stigmatocythere* and lacks the anterior connection to the eye-tubercle present in *Stigmatocythere*. *Bradleya* has only dorsal and ventral ridges. *Carinocythereis* Ruggieri 1956 has a V-shaped frontal scar and small vestibules, characters not found in *Stigmatocythere*.

REMARKS. *Stigmatocythere* is so far only known from the Middle and Upper Eocene of the Sulaiman Range.

Stigmatocythere obliqua sp. nov.

(Plate 35, figs. 1–10 ; Plate 36, figs. 1–2)

DERIVATION OF NAME. Latin *obliqua*, oblique ; with reference to the ventral ridge.

DIAGNOSIS. A strongly reticulate species of *Stigmatocythere* with three well-developed longitudinal ridges including an oblique ventral ridge.

HOLOTYPE. Io. 4355, a female carapace (Plate 35, figs. 2, 5, 6 ; Plate 36, fig. 2).

PARATYPES. Io. 4303 + Io. 3147 + Io. 3148 + Io. 3149.

MATERIAL. Over 1400 specimens from the Rakhi Nala section from 17 horizons (sample nos. 3448, 3451 to 3454, 3456, 3457, 3460 to 3467, 3470 and 3473). 470 specimens from the Zao River section from two horizons (sample nos. 24107 and 24110). Approximately 600 specimens from the Shpalai Khwara section from three horizons (sample nos. 24681, 24683 and 24686). GSP BM 2587–8.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Shales with Alabaster, sample no. 24173.

DESCRIPTION. *Carapace* subrectangular in lateral view. Sexual dimorphism rather pronounced ; the females are shorter, higher and wider than the males. Anterior margin broadly and obliquely rounded, posterior nearly straight. Dorsal margin almost intricate because of the over-reaching of the dorsal ridge, venter slightly incurved in front of the middle. Valves almost equal except that the left valve over-reaches the right in the region of the anterior cardinal angle and along the posterodorsal corner. *Eye-tubercle* and *subcentral-tubercle* distinct. Shell surface strongly reticulate. Three longitudinal ridges present ; the dorsal ridge starts almost above the subcentral node and is arched convexly upwards ; the median ridge commences from the eye-tubercle, curves sharply round to join anterodorsal corner of the subcentral complex and continues posteriorly ; the ventral ridge slopes obliquely upwards towards the posterior. The reticulations in the mid-posterior region of the carapace show a concentric pattern, although it is not always present. A high anterior marginal rim commences from the eye-tubercle continuing as a less high rim round the venter and posterior. Anterior and posterior short marginal spines present, 18–20 anteriorly. *Normal pore canals* simple, some 60 in the female left valve. 24–25 anterior *radial pore canals*, simple straight, irregularly spaced, few crossing one another, mostly terminating in marginal spines. *Inner-margin* and *line of concrescence* coincide. Anterior *duplicature* 0·050 mm. wide in the female left valve. *Selvage* strong in both valves, subperipheral in left valve but in right valve it lies in the outer third of the duplicature. Right valve with deep anterior and ventral *flange grooves*. *Muscle scar* pattern consists of four adductor scars in a vertical row with an oval frontal scar. *Hinge* holamphidont, the details are as follows :

Element	Left valve	Right valve
Anterior	Socket confluent with ocular sinus.	Strongly projecting sub-conical or subpessular tooth with a tendency for the anterior profile in dorsal view to appear concave. The ocular sinus lies distally beyond this and opens to the interior below and in front of it.

Anteromedian	Conical tooth with straight anterior in dorsal view.	Deep socket.
Posteromedian	Denticulate bar.	Locellate shelf, only detectable in best preserved specimens.
Posterior	Deep socket, slightly elongate, open in centre.	Pessular tooth, tending towards reniform in some specimens.

Dimensions (mm).

		L	H	W
Io. 4303	Carapace male	0·61	0·30	0·29
Io. 4355	Carapace female (holotype)	0·54	0·33	0·29
Io. 3149	Left valve female	0·52	0·34	—
Io. 3148	Right valve female	0·54	0·32	—
Io. 3149	Left valve female	0·54	0·34	—
Io. 3146	Right valve female	0·51	0·29	—

Comparison. This species is perhaps ancestral to *Stigmatocythere portentum* sp. nov. which it resembles very closely, but differs in being smaller, having deeper reticulations and less prominent subcentral-tubercle.

Remarks. The present species occurs abundantly in the Shales with Alabaster of the Rakhi Nala, Zao River and Shpalai Khwara sections and seems to be restricted to this formation. It is very likely that this species will prove to be a valuable horizon marker in the region.

The longitudinal ridges in some of the specimens from the upper few horizons of the Rakhi Nala section are exaggerated and in some the dorsal and ventral ridges posteriorly terminate in spines. This is regarded here as specific variation.

Stigmatocythere portentum sp. nov.

(Plate 36, figs. 3–6, 10)

Derivation of name. Latin *portentum*, omen or sign ; with reference to the diagnostic ornamentation.

Diagnosis. A large, reticulate species of the genus *Stigmatocythere* with three distinct longitudinal ridges, prominent subcentral-tubercle.

Holotype. Io. 4357, a male carapace (Pl. 36, figs. 3–6).

Paratypes. Io. 3144 + Io. 3145.

Material. Eight specimens from the locality below from two horizons (sample nos. 3498 and 3499). GSP BM 2551.

Type locality. Rakhi Nala section.

Type horizon. Lower Chocolate Clays, sample no. 3498.

Description. *Carapace* subrectangular in side view with the greatest height at the anterior cardinal angle and the greatest length above mid-point. Anterior

margin broadly rounded, posterior truncated. Dorsal margin straight, but looks irregular in lateral view because of over-reaching of the dorsal ridge ; ventral margin almost straight. Anterior and posterior cardinal angles well-developed particularly in the left valve. Left valve slightly over-reaches the right at the anterior cardinal angle and along the posterodorsal slope. *Eye-tubercle* distinct and rounded. *Subcentral-tubercle* prominent. Surface reticulate with three longitudinal ridges. Dorsal ridge wavy and convex upwards, it begins above the subcentral-tubercle and in the posterodorsal region, curves sharply down to meet the median ridge. A strongly curved ridge runs from the eye-tubercle to the subcentral-tubercle, continuing posteriorly as a median ridge. Ventral ridge commences above the anteroventral corner and is slightly convex downwards. There is a short, curved ridge on the ventral side of the subcentral-tubercle running towards the anterior end. A marginal rim runs along the anterior, ventral and posterior margins. It is high on the anterior but less high along the venter and posterior. Anterior ornamented with short, numerous spines. There is a large posteroventral spine. *Radial pore canals* simple. more or less straight, some crossing one another, few seem to bifurcate, some 25 anteriorly. *Inner margin* and *line of concrescence* coincide ; no *vestibule*. *Duplicature* of moderate width with a well-marked selvage. *Hinge* holamphidont with a projecting conical anterior tooth in the right valve.

Dimensions (mm).

		L	H	W
Io. 4357	Carapace male (holotype)	0·71	0·37	0·32
Io. 3144	Right valve (broken)	—	0·37	—
Io. 3145	Carapace (juvenile)	0·59	0·35	0·29

Comparison. This species has already been compared with *Stigmatocythere obliqua* sp. nov.

Remarks. *S. portentum* is a very rare ostracod and has so far only been found in the uppermost beds of the Lower Chocolate Clays of the Rakhi Nala section.

Stigmatocythere calia sp. nov.

(Plate 36, figs. 7–9 ; Plate 37, figs. 1, 3)

Derivation of name. Greek, *kalia*, bird's nest ; from a fancied appearance of the ornamentation in lateral view.

Diagnosis. A non-reticulate *Stigmatocythere* with straight posterior, high anterior marginal rim, prominent and projecting subcentral-tubercle, dorsal and ventral lines of ornamentation, posteroventral ridge, almost straight.

Holotype. Io. 4353, a female carapace (Pl. 36, figs, 8, 9 ; Pl. 37, figs. 1, 3).

Paratype. Io. 4304.

Material. 15 specimens from the locality below from five horizons (sample nos. 24148, 24150 to 24153). GSP. BM. 2589.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24151.

Description. Sexual dimorphism distinct ; the males are more elongate than the females. *Carapace* subrectangular in lateral outline. Dorsal margin almost straight but appears undulating in side view due to the over-reaching of the dorsal line of ornamentation, ventral margin nearly straight. Anterior margin broadly and evenly rounded, posterior straight, posterodorsal slope almost straight. Left valve slightly over-reaches the right valve in the anterodorsal and posterodorsal corners ; otherwise the two valves are equal. *Eye-tubercle* distinct, rounded and polished. *Subcentral-tubercle* prominent and projecting particularly in dorsal and ventral views. Dorsal line of ornamentation consists of three nodes including a large subangular posterodorsal node which extends vertically down for a short distance. Ventral line of ornamentation consists of two nodes but in some specimens it is just a short ridge. A projecting, almost vertical posteroventral ridge runs from behind the ventral line of ornamentation to a point which is slightly above the mid-line. A curved ridge diagnostic of the genus runs from the eye-tubercle to the subcentral-tubercle ; it is not well-marked. The subcentral-tubercle has two faint, short, curved ridges on its ventral side, one to the anterior and one to the posterior. Anterior marginal rim high, extending along the ventral and posterior margins as a less high rim. Anterior margin set with numerous short spines, concealed in lateral view by the elevated anterior marginal rim. There is one short posterodorsal marginal spine and one short posteroventral marginal spine. Internal details not determinable.

Dimensions (mm).

		L	H	W
Io. 4304	Right valve male	0·61	0·34	—
Io. 4353	Carapace female (holotype)	0·56	0·36	0·32

Stigmatocythere delineata sp. nov.

(Plate 37, figs. 2, 4–10)

Derivation of name. Latin *delineata*, outlined ; from the resemblance of the ornamentation to sketch map.

Diagnosis. A species of the genus *Stigmatocythere* with a large hexagon formed of ridges in the posteromedian region, dorsal ridge broken in the middle and extending vertically below in the posterodorsal region.

Holotype. Io. 4356, a female carapace (Pl. 37, figs. 7–10).

Paratype. Io. 4305.

Material. Six specimens from the type locality from two horizons (sample nos. 24154 and 24155). GSP BM 2590–91.

Type locality. Zao River section.

Type horizon. Upper Chocolate Clays, sample no. 24154.

Description. Sexual dimorphism apparent ; the males are proportionally longer than the females. *Carapace* subrectangular in side view. Dorsal margin slightly concave, ventral margin almost straight, anterior margin broadly and evenly rounded, posterodorsal slope and posteroventral margin nearly straight. Greatest

height lies at the anterior cardinal angle, greatest length above the mid-point and greatest width in the posterior third. Anterior and posterior cardinal angles projecting particularly in the left valve. Left valve slightly over-reaches the right valve in the region of the anterodorsal corner and posterodorsal slope. *Subcentral-tubercle* and *eye-tubercle* distinct. The most prominent part of the ornamentation is a large slightly irregular hexagon formed of ridges just to the posterior of centre. Other short ridges, mostly running outwards, join this hexagon at its corners. A sharply curved ridge characteristic of the genus connects the eye-tubercle and the subcentral tubercle. Dorsal ridge is broken in the middle and in the posterodorsal region it extends vertically below to a point slightly above mid-line. The ventral ridge runs at a slightly oblique angle towards the posterior end, its posterior portion forming the ventral part of the hexagon. A high marginal rim runs on around the anterior margin and continues along the ventral and posterior margins as a less high rim. Anterior margin denticulate, posteroventral corner ornamented with a short spine. *Duplicature* of moderate width with a strong *selvage*. *Hinge* holamphidont.

Dimensions (mm).

		L	H	W
Io. 4305	Carapace male	0·61	0·34	0·29
Io. 4356	Carapace female (holotype)	0·56	0·34	0·29

Comparison. It is easy to separate *S. delineata* from other described species of the genus *Stigmatocythere* due to its characteristic surface ornamentation particularly the large hexagon formed of ridges just to the posterior of centre.

Stigmatocythere lumaria sp. nov.

(Plate 37, figs. 11 ; Plate 38, figs. 1–10 ; Plate 39, figs. 1–8, 11)

Derivation of name. Latin *lumarius*, thorny.

Diagnosis. A species of *Stigmatocythere* with a prominent and bilobate subcentral-tubercle. Surface tuberculate or combination of reticulations and tubercles. Three large, projecting tubercles in the mid-dorsal region.

Holotype. Io. 4354, a male carapace (Pl. 38, figs. 1, 5, 8).

Paratypes. Io. 4306–7 + Io. 3150–4.

Material. Approximately 340 specimens from the Rakhi Nala section from 21 horizons (sample nos. 3621, 3624 to 3628, 3630, 3640 to 3642, 3645 to 3652, 3658, 3662 and 3663). 86 specimens from the Zao River section from 11 horizons (sample nos. 24156, 24157, 24159, 24170, 24173 to 24176, 24180, 24187 and 24193). GSP BM 2592–94.

Type locality. Rakhi Nala section.

Type horizon. Upper Chocolate Clays, sample no. 3642.

Description. Sexual dimorphism rather pronounced ; the females are shorter and higher than the males. *Carapace* subrectangular in lateral view. Anterior margin broadly rounded, posteroventral margin and posterior extremity more or

less rounded, posterodorsal slope very slightly concave. Dorsal margin straight but appears intricate due to surface ornamentation ; ventral margin slightly concave in front of the middle, particularly in right valve. Greatest height lies in the anterior third, greatest length passes above mid-line. Anterior and posterior cardinal angles well-marked. Valves almost equal. *Eye-tubercle* distinct and rounded. *Subcentral-tubercle* prominent and bilobate. Surface ornamentation consists of either tubercles or a combination of reticulations and tubercles. In some cases tubercles become almost spinose. There are three tubercles in the mid-dorsal region and in most specimens these project beyond the dorsal margin in lateral outline. The eye-tubercle is joined to the subcentral-tubercle, by a sharply curved ridge, diagnostic of the genus. The ventral side of the subcentral-tubercle has two weak, short, curved ridges ; one extends towards the anterior and the other towards the posterior end. Anterior marginal rim well-marked, ventral and posterior marginal rims less well-marked. Anterior and posterior margins decorated by short, numerous spines. Posterior has several short spines and two large, somewhat blunt spines, one in the posteroventral corner and the other in the posterodorsal corner. *Radial pore canals*, simple, almost straight, irregularly spaced, some crossing one another, 25–26 anteriorly. *Line of concrescence* and *inner margin* coincide. Anterior *duplicature* moderately wide, one-twelfth of the entire length of the valve. *Selvage* pronounced, in right valve it lies in the outer third of the duplicature but in left valve it is submarginal. Right valve with deep ventral and anterior *flange grooves*. *Adductor scars* in a vertical column of four. *Frontal scar* not clearly seen but appears to be oval in shape. *Hinge* holamphidont with the following details :

Element	Left valve	Right valve
Anterior	Socket bounded on all sides, ocular sinus opening into it.	Strongly projecting conical tooth. Ocular sinus lies below and slightly anterior to it.
Anteromedian	Subconical tooth with straight anterior and convex posterior in dorsal view.	Deep socket bounded on venter and opening into posteromedian groove.
Posteromedian	Denticulate bar.	Locellate groove.
Posterior	Deep socket open in venter.	Tooth more or less rounded in lateral view but pessular in dorsal view.

Comparison. *Stigmatocythere portentum* sp. nov. is larger, than the present species, has three distinct longitudinal ridges, lacks a tuberculate surface and bilobate subcentral-tubercle. *Stigmatocythere calia* sp. nov. is probably ancestral to *S. lumaria* but has a vertical posteroventral ridge and more elevated anterior marginal rim. Further, it lacks a tuberculate surface and bilobate subcentral-tubercle.

This species can be separated into two morphotypes, although it is rather difficult to maintain a distinction between them because of many intermediate forms :

Morphotype A

(Plate 37, figs. 11 ; Plate 38, figs. 1–10 ; Plate 39, fig. 11)

This has a tuberculate surface. Tubercles vary in size and number. Some have few large tubercles with a tendency to become spinose and in others tubercles are small and rounded.

Dimensions (mm).

		L	H	W
Io. 4354	Carapace male (holotype)	0·67	0·37	0·34
Io. 4307	Right valve female	0·63	0·37	—
Io. 4306	Left valve male (juvenile)	0·59	0·32	—
Io. 3151	Right valve male	0·68	0·37	—
Io. 3152	Left valve female	0·59	0·40	—
Io. 3154	Right valve female	0·60	0·37	—

Morphotype B

(Plate 39, figs. 1–8)

This is very similar to Morphotype A, but has a surface ornamentation which is a combination of reticulations and tubercles.

Dimensions (mm).

		L	H	W
Io. 3150	Carapace male	0·66	0·37	0·32
Io. 3153	Carapace female	0·62	0·37	0·31

Remarks. This species has been described as Genus and sp. indet.G. by I. G. Sohn in his paper on Lower Tertiary ostracods from Western Pakistan, still in press.

Genus ***TRACHYLEBERIS*** Brady 1898

Type species. *Cythere scabrocuneata* Brady 1880.

Subgenus ***TRACHYLEBERIS*** sensu stricto

Trachyleberis (Trachyleberis) lobuculus sp. nov.

(Plate 39, figs. 9, 10 ; Plate 40, figs. 1, 3)

Derivation of name. Latin *lobus*, lobe + *oculus*, eye ; with reference to the lobate eye-tubercle.

Diagnosis. A species of the subgenus *Trachyleberis* in which eye-tubercle is lobate, surface ornamented with tubercles, posterior cardinal angle well-marked in left valve.

Holotype. Io. 4364, a female carapace (Pl. 40, figs. 1, 3).

Paratype. Io. 4308.

MATERIAL. 287 specimens from the locality below from 49 horizons (sample nos. 3147, 3160, 3162, 3163, 3166, 3167, 3169 to 3171, 3173 to 3175, 3177 to 3180, 3183 to 3193, 3197 to 3200, 3401 to 3404, 3407, 3409, 3410, 3415, 3417 to 3422, 3428, 3429, 3434 and 3435). GSP BM 2595–6.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Upper Rakhi Gaj Shales, sample no. 3166.

DESCRIPTION. *Carapace* subrectangular in the male dimorph and sub-quadrate in the female. Sexual dimorphy apparent, the males being larger in proportion to the females. Dorsal and ventral margins subparallel (undulating in lateral view because of surface ornamentation). Anterior margin broadly rounded, posterodorsal margin almost straight, posterior extremity somewhat rounded, posterodorsal margin curved. Greatest height at anterior cardinal angle and greatest length in the middle. Valves more or less equal. *Eye-tubercle* lobate and prominent situated just below a well-developed anterior cardinal angle. Posterior cardinal angle well-marked in the left valve, armed with a node or short spine pointing upwards. *Subcentral-tubercle* distinct. Both anterior and posterior margins ornamented with a double row of tubercles or very short spines. Surface tuberculate or nodose (occasionally tubercles or nodes develop into spines). Anterior and posterior marginal rim more or less distinct. *Hinge* holamphidont : left valve with terminal sockets, postjacent conical tooth and median denticulate bar ; right valve hinge complimentary (anterior tooth being conical). *Duplicature* of moderate width with a submarginal *selvage*. Other internal details not determinable.

DIMENSIONS (mm).

		L	H	W
Io. 4308	Carapace male	0·61	0·34	0·24
Io. 4364	Carapace female (holotype)	0·59	0·35	0·28

COMPARISON. *T. lobuculus* is probably related to *Cythereis spinellosa* Lubimova and Guha (1960) but differs in having a lobate eye-tubercle and a different lateral outline and surface ornamentation.

REMARKS. Specimens of *Cythereis spinellosa* Lubimova and Guha were not available for comparison, but from the description and figure given by these authors it appears that the eye-tubercle in that particular species is not lobate.

Trachyleberis (Trachyleberis) bimammillata sp. nov.

(Plate 40, figs. 2, 4–11)

DERIVATION OF NAME. Latin *bimammillata*, two-breasted ; with reference to the split subcentral-tubercle.

DIAGNOSIS. A small species of the subgenus *Trachyleberis* in which subcentral-tubercle is divided into two horizontally disposed nodes and posterodorsal process consisting of two vertically arranged nodes.

HOLOTYPE. Io. 4363, a male carapace (Pl. 40, figs. 2, 8, 10).

PARATYPES. Io. 3155–9.

MATERIAL. 42 specimens from the Rakhi Nala section from 5 horizons (sample nos. 3610, 3613 to 3615 and 3617). 7 specimens from the Zao River section from two horizons (sample nos. 24150 and 24152). GSP BM 2597.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Upper Chocolate Clays, sample no. 3613.

DESCRIPTION. *Carapace* subrectangular to subquadrate in lateral outline. Sexual dimorphism moderate ; the presumed males are longer and less high than the females. Dorsal and ventral margins straight and tapering towards the posterior. Anterior margin broadly rounded, posterodorsal slope very slightly concave, posterior extremity rounded, posterodorsal margin somewhat rounded. Anterior, posterior and ventral margins decorated with a double row of short spines, but dorsal margin with only one row of very short spines (these in some specimens almost look like pustules). Greatest height at the anterior cardinal angle (which is obtuse and angular) and greatest length through the mid-point. In dorsal view the greatest width lies at the anterior node of the subcentral-tubercle. Valves almost equal. *Eye-tubercle* rounded and distinct. *Subcentral-tubercle* divided into two nodes, horizontally arranged, the anterior one being larger (spinose in some specimens). The posterodorsal process consists of two nodes (spines in some specimens), which are vertically disposed. In a few specimens a posteroventral node is also present. Surface ornamented with scattered tubercles and spines. *Duplicature* fairly wide. The *selvage* is subperipheral and well-developed in both valves. *Radial pore canals* not seen because of mineralization. The *adductor muscle scars* are in an oblique row of four at the posterior margin of the subcentral pit. The *frontal scar* is large and U-shaped and opens towards the anterodorsal corner. *Hinge* holamphidont with the following details :—

Element	Left valve	Right valve
Anterior	Socket.	Projecting subconical tooth.
Anteromedian	Subconical tooth.	Socket.
Posteromedian	Denticulate ridge.	Locellate groove.
Posterior	Fairly deep socket.	Tooth, subpessular in dorsal view.

DIMENSIONS (mm).

		L	H	W
Io. 4363	Carapace male (holotype)	0·52	0·29	0·22
Io. 3159	Carapace female	0·50	0·29	0·24
Io. 3158	Left valve male (broken)	—	0·29	—
Io. 3156	Left valve female	0·50	0·29	—
Io. 3155	Right valve female	0·49	0·29	—
Io. 3160	Carapace male	0·54	0·29	0·22
Io. 3157	Carapace female	0·49	0·29	0·24

COMPARISON. This species can easily be distinguished from *Trachyleberis* (*Trachyleberis*) *lobuculus* sp. nov. by its smaller size, slightly concave posterodorsal margin and split subcentral-tubercle. Further, *Trachyleberis* (*Trachyleberis*) *bimammillata*

has a posterodorsal process consisting of two nodes in a vertical row and lacks a lobate eye-tubercle.

Subgenus *ACANTHOCYTHEREIS* Howe 1963

TYPE SPECIES. *Acanthocythereis araneosa* Howe 1963.

Trachyleberis (Acanthocythereis) procapsus sp. nov.

(Plate 40, figs. 12, 13 ; Plate 41, figs. 1, 3, 4)

DERIVATION OF NAME. Latin *procapsus*, anterior cage ; with reference to the smooth walled area enclosed behind the anterior marginal rim.

DIAGNOSIS. *Acanthocytheris* in which a smooth walled area lies behind the anterior marginal rim, anterior and posterior platforms compressed.

HOLOTYPE. Io. 4360, a male carapace (Pl. 40, fig. 12 ; Pl. 41, figs. 1, 3).

PARATYPE. Io. 3164.

MATERIAL. Six specimens from the locality below from two horizons (sample nos. 460-j and 460-i). GSP BM 2598.

TYPE LOCALITY. Sor Range section.

TYPE HORIZON. Upper Palaeocene, sample no. 460-j.

DESCRIPTION. Sexual dimorphism apparent ; the males are longer in proportion to the females. *Carapace* elongate, subrectangular in lateral outline with dorsal and ventral margins almost straight, tapering towards the posterior. Anterior margin broadly rounded, posterior subtriangular. Anterior cardinal angle rounded. Left valve over-reaches the right very slightly at the posterodorsal margin. Greatest height through the anterior cardinal angle and greatest length through the mid-point. In dorsal view the greatest width is situated at the anterior third. *Sub-central-tubercle* distinct. *Eye-tubercle* rounded and distinct and lies at the anterior cardinal angle. Surface reticulate (reticulae joined by walls or pustules or papillae). Posterodorsal process consists of small more or less rounded protuberances. Anterior and posterior margins ornamented by a double row of short spines. Anterior and posterior marginal rims high with a smooth walled area behind. Internal details not known.

DIMENSIONS (mm).

		L	H	W
Io. 4360	Carapace male (holotype)	0·68	0·32	0·20
Io. 3164	Carapace female	0·59	0·30	0·20

COMPARISON. This species is distinguishable from *Trachyleberis* (*Acanthocythereis*) *usitata* sp. nov. by its deeper reticulation, more elevated marginal rims and spinose anterior and posterior margins.

The present species has already been compared with *Trachyleberis* (*Acanthocythereis*) *postcornis* sp. nov. and *Trachyleberis* (*Acanthocythereis*) *decoris* sp. nov.

Remarks. *T.* (*A.*) *procapsus* has so far only been recovered from the Upper Palaeocene of the Sor Range section.

Trachyleberis (Acanthocythereis) usitata sp. nov.

(Plate 41, figs. 2, 5, 7)

Derivation of name. Latin *usitatus*, usual.

Diagnosis. Carapace tapering towards posterior. Subcentral-tubercle distinct. Surface reticulate with superimposed pustules and a posterodorsal process.

Holotype. Io. 4362, a male carapace (Pl. 41, fig. 2).

Paratype. Io. 3161.

Material. Five specimens from the Rakhi Nala section from four horizons (sample nos. 3111, 3130, 3132 and 3133). GSP BM 2599.

Type locality. Rakhi Nala section.

Type horizon. Gorge Beds, sample no. 3111.

Description. Sexual dimorphy present ; the males are longer in proportion to the females. *Carapace* elongate, subrectangular, tapering towards the posterior. Anterior margin broadly rounded, posterior narrowly rounded. Dorsal and ventral margins almost straight. Greatest height at the anterior cardinal angle which is well-developed in the left valve. Greatest length passes through mid-point. Valves almost equal. In dorsal view greatest width lies in the anterior third (in the region of the subcentral-tubercle). *Eye-tubercle* rounded and distinct. *Subcentral-tubercle* fairly distinct. Anterior and posterior marginal rims sharply defined. Surface reticulate with pustules at reticulae intersections. A posterodorsal process in the form of more or less rounded tubercle of medium size present. A double row of pustules decorates anterior and posterior margins. Internal characters not known.

Dimensions (mm).

		L	H	W
Io. 4362	Carapace male (holotype)	0·63	0·32	—
Io. 3161	Carapace female	0·59	0·32	0·22

Comparison. This species shows some resemblance to *Trachyleberis* (*Acanthocythereis*) *decoris* sp. nov. but is smaller, has marginal pustules rather than spines and carapace more tapering towards the posterior. *Trachyleberis* (*Acanthocythereis*) *postcornis* has a characteristic posterodorsal process, more high marginal rims and spinose anterior and posterior margins.

Remarks. In some specimens the posterodorsal process is not well-developed.

Trachyleberis (Acanthocythereis) pedigaster sp. nov.

(Plate 41, figs. 6, 8)

Derivation of name. Greek *pedigaster*, flat belly ; with reference to the ventral inflation.

Diagnosis. A large species of the subgenus with ventral inflation. Carapace tapering towards posterior. Posterior margin subtriangular.

HOLOTYPE. Io. 4358, a carapace.

MATERIAL. Only one specimen from the locality and horizon below.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Lower Rakhi Gaj Shales, sample no. 3671.

DESCRIPTION. *Carapace* large, elongate, tapering towards posterior and with ventral inflation. Anterior and posterior marginal platforms compressed. Dorsal and ventral margins almost straight, anterior margin broadly rounded, posterior subtriangular. Anterior and posterior cardinal angles well-developed particularly in the left valve. Left valve slightly larger than the right, which it over-reaches in the region of the anterodorsal corner and posterodorsal slope. *Eye-tubercle* rounded and distinct and lies just below the anterior cardinal angle. *Subcentral-tubercle* more or less distinct. Greatest height through the anterior cardinal angle, greatest length below mid-point and greatest width a little posterior to the middle. Surface ornamentation consists of reticulations with superimposed papillae. The posterodorsal process consists of two almost rounded small tubercles (or papillae) joined together in the left valve and one small rounded tubercle in the right. Anterior and posterior marginal rims fairly distinct. Anterior and posterior margins ornamented with a double row of papillae. Internal details unknown.

DIMENSIONS (mm).

		L	H	W
Io. 4358	Carapace (holotype)	1·02	0·51	—

COMPARISON. There is no difficulty in separating *T.* (*A.*) *pedigaster* sp. nov. from other described species of the subgenus *Acanthocythereis* by its large carapace and subtriangular posterior.

Trachyleberis (Acanthocythereis) postcornis sp. nov.

(Plate 41, figs. 9, 10; Pl. 42, figs. 1, 2, 7, 10)

DERIVATION OF NAME. Latin *post*, posterior + *cornis*, horned ; with reference to the posterodorsal process.

DIAGNOSIS. A species of the subgenus *Acanthocythereis* with distinct subcentral-tubercle and eye-tubercle. Surface reticulate with small superimposed spines. Posterodorsal process divided into two spines.

HOLOTYPE. Io. 4361, a male carapace (Pl. 42, figs. 1, 2, 7, 10).

PARATYPES. Io. 4309+3162–4.

MATERIAL. 45 specimens from the locality below from two horizons (sample nos. 3498 and 3499) and 3 specimens from the Zao River section from two horizons (sample nos. 24131 and 24148). GSP BM 2600.

TYPE LOCALITY. Rakhi Nala section.

TYPE HORIZON. Lower Chocolate Clays, sample no. 3499.

DESCRIPTION. *Carapace* elongate, subrectangular in lateral outline with dorsal and ventral margins straight, tapering towards the posterior. Anterior margin

broadly and evenly rounded, posterior slightly sub-triangular in right valve but almost rounded in the left, posterodorsal margin very slightly concave. Anterior and posterior cardinal angles well-developed. Sexual dimorphism rather strong ; the presumed males are longer, less high and less wide than the females. Valves almost equal. In dorsal view greatest width lies at the anterior third (in the region of the subcentral-tubercle). *Eye-tubercle* rounded, polished and prominent (standing out from the carapace). *Subcentral-tubercle* distinct. Surface ornamentation consists of combination of reticulations and small spines. The posterodorsal process is divided into two spines (although in some specimens this division is not detectable). In a few specimens a posteromedian process is also developed. The anterior and posterior margins are decorated with a double row of spines ; the second row lies on high anterior and posterior marginal rims. The posterior marginal spines are larger and less in number. *Duplicature* fairly wide. *Selvage* prominent and submarginal. *Radial pore canals* not clearly displayed because of mineralization, but appear to be simple, more or less straight with median swellings, 30–35 anteriorly. *Hinge* holamphidont :

Element	Left valve	Right valve
Anterior	Socket.	Stirpate tooth.
Anteromedian	Subconical tooth.	Deep socket.
Posteromedian	Locellate shallow groove.	Denticulate bar.
Posterior	Deep socket.	Tooth, almost rounded in lateral view.

Dimensions (mm).

		L	H	W
Io. 4361	Carapace male (holotype)	0·62	0·30	0·22
Io. 3162	Carapace female	0·52	0·29	0·21
Io. 3164	Right valve male	0·61	0·29	—
Io. 3163	Right valve female	0·50	0·28	—

Comparison. The present species shows some affinity to *Trachyleberis* (*Acanthocythereis*) *decoris* sp. nov. but is shorter, less high and less wide. These two species also differ in surface ornamentation. *T.* (*A.*) *postcornis* has a combination of reticulations and small spines, while *T.* (*A.*) *decoris* is reticulate with superimposed pustules. Further, *T.* (*A.*) *postcornis* has a well-developed posterodorsal process divided into two spines and a distinct subcentral-tubercle. This species may also be distinguished from *T.* (*A.*) *procapsus* sp. nov. in being smaller and lacking a smooth walled area behind the anterior marginal rim. These two species also differ in dorsal outline.

Trachyleberis (Acanthocythereis) decoris sp. nov.

(Plate 42, figs. 3–6, 8, 9)

Derivation of name. Latin *decoris*, beautiful, adorned ; with reference to the bejewelled appearance of the pustules and reticulae.

Diagnosis. *Acanthocythereis* in which surface ornamentation consists of reticula-

tions with superimposed pustules. Carapace subrectangular with dorsal and ventral margins almost straight and subparallel.

Holotype. Io. 4359, a male carapace (Pl. 42, figs. 3, 4, 5).

Paratype. Io. 4310.

Material. Over 250 specimens from the type locality from 18 horizons (sample nos. 3604, 3607, 3610, 3613 to 3615, 3629, 3640, 3642, 3645, 3648 to 3650, 3661 to 3664). 7 specimens from the Zao River section from 3 horizons (sample nos. 24154, 24173 and 24193). GSP BM 2601–2.

Type section. Rakhi Nala section.

Type horizon. Upper Chocolate Clays, sample no. 3640.

Description. Sexual dimorphism rather marked ; the males are longer in proportion than the females. *Carapace* subrectangular in lateral view with dorsal and ventral margins almost straight and subparallel. Anterior margin broadly and evenly rounded, posterior slightly subtriangular. Both anterior and posterior margins ornamented by a double row of short spines, the posterior ones being larger. Anterior cardinal angle rounded, posterior cardinal angle well-marked. Greatest height at the anterior cardinal angle and greatest length in the middle. In dorsal view greatest width lies in the anterior third. Valves almost equal. Surface reticulate with superimposed pustules. *Eye-tubercle* rounded and distinct. *Subcentral-tubercle* more or less distinct (better seen in slightly worn specimens). A large number of specimens (particularly the females) show development of posteroventral prominence. In a few specimens a small posterodorsal process also develops, but these characters here are regarded as variations within the species. *Duplicature* fairly wide with a submarginal *selvage*. *Radial pore canals* not seen. *Muscle scar* pattern consists of four adductors in a vertical superposition at the posterior margin of the muscle scar pit with a U-shaped frontal scar opening towards the anterodorsal corner. *Hinge* holamphidont :

Element	Left valve	Right valve
Anterior	Socket.	Slightly stirpate tooth.
Anteromedian	Subconical tooth.	Denticulate ridge.
Posterior	Deep socket.	Somewhat rounded tooth in lateral view.

Dimensions (mm).

		L	H	W
Io. 4359	Carapace male (holotype)	0·67	0·32	0·24
Io. 4310	Carapace female	0·59	0·32	0·23

Comparison. In some respects this species resembles *Trachyleberis* (*Acanthocythereis*) *procapsus* sp. nov., but differs in lacking the smooth walled area enclosed by the anterior marginal rim and compressed anterior and posterior marginal platforms. These two species also differ in size, *T.* (*A.*) *decoris* being smaller, higher and wider in proportion than *T.* (*A.*) *procapsus*.

Remarks. This species commonly occurs in the Upper Chocolate Clays of the Rakhi Nala section but it is very rare in the Zao River section.

V. OSTRACODA AND EARLY TERTIARY CORRELATION IN THE SULAIMAN RANGE

(a) Biostratigraphic Units

Throughout the succession the ostracods have revealed a fairly shallow-water marine environment. Although Eames (1952a) has recorded small freshwater gastropods in the lower part of the Lower Chocolate Clays (in his local zones 8 & 9) of the Rakhi Nala section, he believes they were carried down from a closely neighbouring source and deposited under estuarine conditions. No freshwater ostracods have been found, however, and the presence of *Neocyprideis* sp. in the Shales with Alabaster could represent either estuarine or super saline conditions.

Except for a few gaps, ostracods occur throughout almost the whole succession. At many horizons, particularly in the Eocene, samples are completely crowded with ostracods. The diversity of the fauna being suggestive of ideal conditions. They usually occur in association with larger and smaller benthonic Foraminifera, but are very rare or almost absent in samples with rich pelagic Foraminifera. The most conspicuous gap in the Eocene succession of the Rakhi Nala and Zao River sections which has not yielded any ostracods is the Platy Limestone and the lower part of the Lower Chocolate Clays. In the Zao River section the top 600 ft. of the Upper Chocolate Clays are devoid of any recognizable ostracods, although at a few horizons some *Nummulites* have been found.

Rakhi Nala Section

The following ostracod biostratigraphic units in the Rakhi Nala section have been recognized (see Table 4). Each unit is identified by a distinct ostracod fauna, a change of faunal suite marking the base.

Ostracod Biostratigraphic Unit I, Palaeocene (lower part)

The first Tertiary ostracod assemblage is encountered in the lower part of the Gorge Beds (samples from the *Venericardia* Shales were not available for study). Seven out of the eight species recorded are restricted to the unit. The species which ranges up into Unit II is *Trachyleberis* (*Acanthocythereis*) *usitata* sp. nov. *Alocopocythere rupina* sp. nov., *Neocyprideis* ? sp.A and *Bairdia* sp.A are abundant and make up over 80% of the ostracod fauna.

Ostracod Biostratigraphic Unit II, Palaeocene (upper part)

This Unit contains the Lower Rakhi Gaj Shales. Ostracods are very rare and have only been found in the upper part which is very rich in pelagic Foraminifera. The ostracods, although very rare, are easily distinguishable from the assemblages below and above. Of the eight species found, all are restricted to the present Unit, with the exception of *Trachyleberis* (*Acanthocythereis*) *usitata* sp. nov. which is also present in the underlying Unit.

Ostracod Biostratigraphic Unit III, Lower Eocene (lower part)

This includes the Upper Rakhi Gaj Shales, Green and Nodular Shales and Rubbly Limestones. Eames' local zones 3, 4, 5 and 6 lie in this Unit.

This is the first Eocene ostracod assemblage. It is fairly rich and at several horizons the ostracods are very abundant. None of the Palaeocene species survive and a completely new fauna evolves. The ostracod fauna is of changing suite ; species appear and disappear in the unit, but there seems to be no major break of any kind in the fauna. *Trachyleberis* (*Trachyleberis*) *lobuculus* sp. nov., *Gyrocythere parvicarinata* sp. nov., *Occultocythereis peristicta* sp. nov. (with five morphotypes), *Schizocythere* sp.A and *Pontocythere* sp.A are the most important members restricted to the unit. Approximately 50% of the species range up into the overlying Unit IV.

Ostracod Biostratigraphic Unit IV, Lower Eocene (*upper part*)

This consists of the Shales with Alabaster and includes Eames' local zone 7. It has a very rich ostracod faunal assemblage. Most of the samples studied were extremely rich in ostracods, which are mostly complete carapaces. The most typical species confined to the unit are *Stigmatocythere obliqua* sp. nov., *Phalcocythere dissenta* sp. nov. Genus C sp. 1 and Genus C sp. 2. More than 50% of the species are restricted to the unit, although approximately 44% are common to Unit III, and only one species ranges up into Unit V.

Ostracod Biostratigraphic Unit V, Middle—Upper Eocene

This comprises the Platy Limestone, Lower Chocolate Clays, Upper Chocolate Clays and *Pellatispira* Beds. Eames' local zones 8 to 15 and Latif's top six pelagic foraminiferal zones occur in this unit. The lowest 730 ft., which form the Platy Limestone and most of the Lower Chocolate Clays, excluding the top 30 ft., are devoid of any recognizable ostracods and are provisionally included in the unit. There are 200 ft. of covered sediments in the Lower Chocolate Clays below sample 3494.

The Unit is very rich in very well-preserved ostracods. It differs markedly from the underlying Unit. All the species except *Alocopocythere transcendens* sp. nov., which survives from the Unit below, appear for the first time, although a few have their ancestors in the Unit IV. The first appearance of ostracods in the Unit is in the uppermost part of the Lower Chocolate Clays (sample nos. 3498 and 3499), which lies at the base of the *Globigerina yeguaensis* zone of Latif. The ostracod fauna is varied and of changing suite. 12% of the species are restricted to the Lower Chocolate Clays (topmost portion) ; 25% are confined to the Upper Chocolate Clays (lower part) ; and only 8% have been recorded from the *Pellatispira* Beds. 33% of the species are shared between the Lower Chocolate Clays (topmost portion) and Upper Chocolate Clays (lower part) ; 17% range from the Lower Chocolate Clays (uppermost part) to the Upper Chocolate Clays (upper part) ; 37% are shared between the Upper Chocolate Clays (lower part) and Upper Chocolate Clays (upper part) ; 8% range from the Upper Chocolate Clays (lower part) to the *Pellatispira* Beds ; and 12% are found in both the Upper Chocolate Clays (upper part) and *Pellatispira* Beds. (The percentages are approximate and are based on the entire ostracod fauna of the Unit).

The genus *Alocopocythere* nov. occurs abundantly almost throughout the Unit.

Alocopocythere transcendens sp. nov., which ranges up from the underlying Units III and IV, is replaced by *A. transversa* sp. nov. just above the middle of the lower part of the Upper Chocolate Clays. This last species has several morphotypes ; in the upper part of the Upper Chocolate Clays the papillose form becomes more common and in the *Pellatispira* Beds this is the only morphotype present. *Stigmatocythere obliqua* sp. nov., which was very abundant in the underlying biostratigraphic Unit IV, is replaced by the larger *Stigmatocythere portentum* sp. nov., which has only been found in the uppermost part of the Lower Chocolate Clays. Higher up in the succession, i.e. in the lower part of the Upper Chocolate Clays the place of *S. portentum* is taken by *Stigmatocythere lumaria* sp. nov. which ranges up into the *Pellatispira* Beds. The genera *Cytherella, Cytherelloidea, Krithe,* and *Paijenborchella* are represented by several species. The genus *Gyrocythere* nov. has two species in the Unit. *Gyrocythere perfecta* sp. nov. occurs in the uppermost part of the Lower Chocolate Clays but in the lower part of the Upper Chocolate Clays it is replaced by the larger *Gyrocythere exaggerata* sp. nov. The subgenera *Scelidocythereis* nov. and *Paracosta* nov. are represented by two and three species respectively. *Paracosta* is known so far only from this Unit. The following are some of the most important species of the Unit : *Bairdoppilata* sp.A, *Cytherelloidea* cf. *C. costatruncata* Lubimova and Mohan, *Cytheromorpha* sp.A, *Cytheropteron* sp.D, *Alocopocythere transversa* sp. nov. (with six morphotypes), *Patagonacythere* ? *nidulus* sp. nov., *Stigmatocythere lumaria* sp. nov. (with two morphotypes) and *Trachyleberis* (*Acanthocythereis*) *decoris* sp. nov.

Zao River Section

The two biostratigraphic Units IV and V of the Rakhi Nala section are found in the Zao River section (see Table 5).

Ostracod Biostratigraphic Unit IV, Lower Eocene (upper part)

This is very similar to biostratigraphic Unit IV of the Rakhi Nala section. The base of the Unit has been taken arbitrarily at the base of the four foot limestone, which lies 332 ft. below the base of the Platy Limestone. The actual base of the Unit, or the Shales with Alabaster, probably lies much lower in the succession, but sediments below the 4 ft. limestone have not been analysed. These have been recorded as the undifferentiated Ghazij by the collectors. No megafossils have so far been recorded from these sediments and it is unlikely that these would yield any smaller foraminifera or ostracods because of their lithology—mostly silty shales.

Ostracods have been found in the upper part of the Unit at two horizons (samples 24107 and 24110). They are extremely abundant in 24107. Approximately half of the Rakhi Nala species of the Unit are found in the Zao River section. None of the species range up into Unit V. *Stigmatocythere obliqua* sp. nov. is the most dominant species and makes about one-third of the ostracod fauna. *Neocyprideis* ? sp.B, *Neocyprideis* sp.C, *Pontocyprella* sp.B, *Pontocyprella* sp.C, *Xestoleberis* sp.C, *Xestoleberis* sp.D, *Xestoleberis* sp.E, Genus C sp.1 and Genus C. sp.2 are some other important species.

Ostracod Biostratigraphic Unit V, Middle-Upper Eocene

The biostratigraphic Unit V of the Rakhi Nala section occurs in the Zao River and is 3743 ft. thick. The Unit includes the Platy Limestone, Lower Chocolate Clays and both lower and upper parts of the Upper Chocolate Clays. The *Pellatispira* Beds have not been recorded in the Zao River section. The bottom 460 ft. of the Unit comprising the Platy Limestone and the lower part of the Lower Chococlate Clays and the top 600 ft. of the upper part of the Upper Chocolate Clays have not yielded any ostracods and are only provisionally included in the Unit.

The Unit is very rich in well-preserved ostracods. The ostracod fauna is completely new since none of the species from the Unit below survive. There are 7% of the species which are restricted to the upper part of the Lower Chocolate Clays ; 26% have only been found in the lower part of the Upper Chocolate Clays ; and 17% have been recorded from the upper part of the Upper Chocolate Clays only. 24% of the species occur in the upper part of the Lower Chocolate Clays and the lower part of the Upper Chocolate Clays ; 13% range from the upper part of the Lower Chocolate Clays to the upper part of the Upper Chocolate Clays and 41% are shared between the lower and upper parts of the Upper Chocolate Clays.

The ostracod fauna of the Unit in the Zao River section is very similar to that of the Rakhi Nala section. It has about 74% of its species in common with the Rakhi Nala. These are shown in Appendix 2. As in the Rakhi Nala, *Alocopocythere* is one of the commonest genera and it occurs in great abundance at several horizons. It is represented by three related species ; *A. transcendens* sp. nov., *A. transversa* sp. nov. (with six morphotypes), and *A. radiata* sp. nov. *Stigamatocythere* is another common genus and has three species in the Unit : *S. calia* sp. nov., *S. delineata* sp. nov. and *S. lumaria* sp. nov. (with two morphotypes). Among these, *S. lumaria* is the commonest, occurring in the lower and upper parts of the Upper Chocolate Clays. *S. calia* and *S. delineata* have so far not been found in the Rakhi Nala section. *Bairdoppilata* sp.A, *Pterygocythereis* (*Pterygocythere*) sp.A are more common in the Zao River section. *Trachyleberis* (*Acanthocythereis*) *decoris* sp. nov. and *Cytheromorpha* sp.A, which were very common in the Rakhi Nala are rare in the Zao River. The subgenus *Paracosta* nov. which is represented by three species in the Rakhi Nala has not so far been recorded from the Zoa River. *Phalcocythere spinosa* sp. nov. and *Quadracythere* (*Hornibrookella*) *subquadra* sp. nov. have only been found in sample 24161 of the Zao River section, where they occur in association with the larger foraminifera *Pellatispira orbitoidea*. Some of the more important members of the unit are : *Alocopocythere transcendens* sp. nov., *Alocopocythere transversa* sp. nov., *Bairdoppilata* sp.A, *Cytherelloidea* cf. *C. costatruncata* Lubimova and Mohan, *Patagonacythere* ? *nidulus*, sp. nov. and *Stimatocythere lumaria* sp. nov.

Shpalai Khwara Section

The ostracod biostratigraphic Unit IV of the Rakhi Nala and Zao River sections is also represented in the Shpalai Khwara section.

Ostracod Biostratigraphic Unit IV, Lower Eocene (upper part)

Like the Zao River section, the base of the Unit is taken arbitrarily at the base of the 4 ft. limestone, which is 320 ft. below the base of the Platy Limestone. The Platy Limestone is only 40 ft. thick in this section. The 12,450 ft. thick sediments below the 4 ft. limestone are barren except for a few horizons which contain poorly preserved pelagic Foraminifera. These probably represent the following lithological units in ascending order : Upper Rakhi Gaj Shales, Green and Nodular Shales, Rubbly Limestones and lower part of the Shales with Alabaster.

Only the upper part of the Unit has yielded ostracods and the fauna is similar to that of the Zao River and Rakhi Nala sections. About 70% of its species are in common with the Zao River section. Over 40% of the species of the Unit in the Rakhi Nala have been recorded from the Shpalai Khwara section. *Stigmatocythere obliqua* sp. nov. is very abundant, particularly in sample 24686, which is absolutely crowded with this species. Some other common species are : *Neocyprideis* ? sp. B, *Pontocyprella* sp.B, *Cytherella* sp.B, *Cytherella* sp. and Genus C sp.2.

(b) Statistical Correlation of ranges of Ostracod Species Common to the Rakhi Nala and Zao River Sections.

The tops and bases of ostracod species common to the Rakhi Nala and Zao River sections have been plotted on a graph (Fig. 6). These fall into two rectilinear patterns, one in biostratigraphic Unit IV and the other in biostratigraphic Unit V.

The tops and bases of ostracod species in biostratigraphic Unit IV (i.e in the Shales with Alabaster) lie almost in a straight line on the graph ; this, however, is because ostracods have only been found at two horizons in the Zao River section. The Equations of Correlation for the array of biostratigraphic Unit V (i.e. above the Platy Limestone) can be computed from the data given in Appendix 2. This method has been discussed in detail by A. B. Shaw in his book 'Time in Stratigraphy', published in 1964. The points marked '+' in Appendix 2 have been omitted because they fall outside the main array. Eighty-one points have been considered. The Equations of Correlation between the Rakhi Nala and Zao River sections can be calculated as follows :

$$\hat{RN} = \bar{RN} + \frac{\Sigma(RN-\bar{RN})\,(ZR-\bar{ZR})}{\Sigma(ZR-\bar{ZR})^2}\,(ZR-\bar{ZR}),$$ where RN = Rakhi Nala and ZR = Zao River.

$$= 6638 + \frac{21{,}675228}{48{,}697965}\,(ZR-2253)$$

$$= 0{\cdot}4451\,ZR + 5635{\cdot}2 \qquad (1)$$

and

$$\hat{ZR} = \bar{ZR} + \frac{\Sigma(RN-\bar{RN})\,(ZR-\bar{ZR})}{\Sigma(RN-\bar{RN})^2}\,(RN-\bar{RN})$$

$$= 2253 + \frac{21,675228}{11,153941}(RN—6638)$$

$$= 1{\cdot}9433\,RN—10646{\cdot}5 \qquad (2)$$

Any point in the Zao River section in biostratigraphic Unit V can be correlated with the corresponding point in the Rakhi Nala section by means of Equation (1). Similarly any point in the Rakhi Nala section can be correlated with the corresponding point in the Zao River section by using Equation (2).

The Coefficient of Correlation is expressed by the formula :

$$r = \sqrt{b_1 \times b_2}$$

By substituting the values b_1 and b_2, we get

$$r = \sqrt{0{\cdot}4451 \times 1{\cdot}9433}$$
$$= \sqrt{0{\cdot}8649}$$
$$= 0{\cdot}930$$

This high value of r is above the 99% confidence level.

The standard error of estimate for $\hat{RN}$ ($S_{\hat{RN}}$)

$$= \sqrt{\frac{\Sigma(RN—\hat{RN})^2}{N}}$$

where $RN—\hat{RN}$ is the difference between each observed point and its computed equivalent and N is the number of entries.

Hence,
$$S_{\hat{RN}} = \sqrt{\frac{1484288{\cdot}91}{81}}$$
$$= \sqrt{18324{\cdot}554}$$
$$= 135{\cdot}4\text{ ft.}$$

The standard error of estimate for $\hat{ZR}$ ($S_{\hat{ZR}}$)

$$= \sqrt{\frac{(ZR—\hat{ZR})^2}{N}}$$

$$= \sqrt{\frac{6464244{\cdot}61}{81}}$$

$$= \sqrt{79805{\cdot}489}$$
$$= 282{\cdot}5\text{ ft.}$$

When the two straight lines given by Equations (1) and (2) are drawn on a graph, they intersect one another at an angle of 3°. Since the Rakhi Nala section has been regarded as the standard section, therefore, for practical purposes only one straight

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nes and Nagappa.

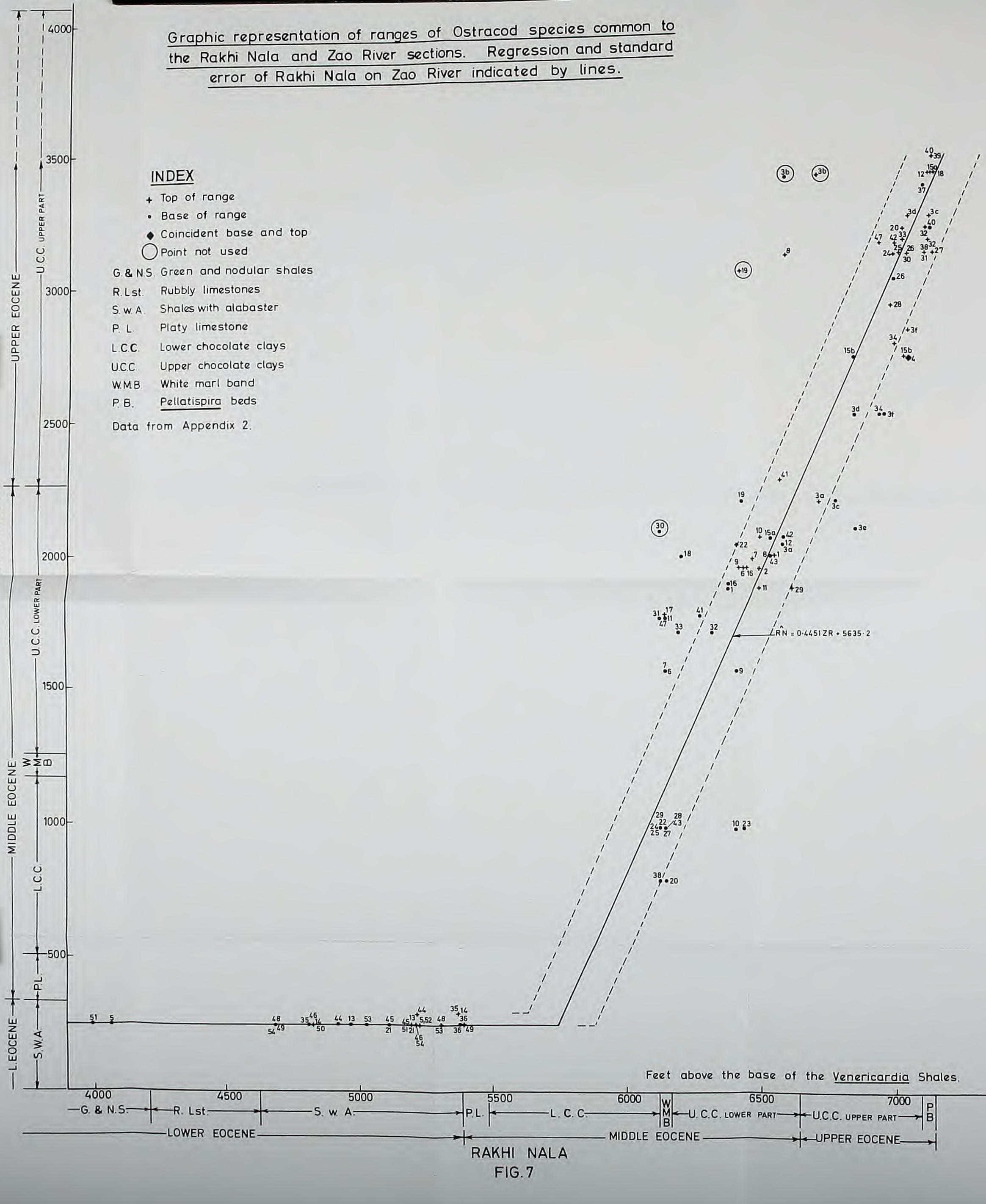
Graphic representation of ranges of Ostracod species common to the Rakhi Nala and Zao River sections. Regression and standard error of Rakhi Nala on Zao River indicated by lines.

INDEX

+ Top of range
• Base of range
◆ Coincident base and top
◯ Point not used

G. & N.S. Green and nodular shales
R. Lst. Rubbly limestones
S. w. A. Shales with alabaster
P. L. Platy limestone
L.C.C. Lower chocolate clays
U.C.C. Upper chocolate clays
W.M.B. White marl band
P. B. Pellatispira beds

Data from Appendix 2.



RAKHI NALA

FIG. 7

line (i.e. $\hat{RN} = 0{\cdot}4451ZR + 5635{\cdot}2$) has been drawn on the graph. This is the Correlation or Regression Line of the Rakhi Nala on the Zao River with parallel dotted lines showing the standard error of estimate.

(c) Conclusions

The Palaeocene and Eocene of the Rakhi Nala section can be divided into five distinct biostratigraphic units on the basis of Ostracoda. Two of these Units, I and II, occur in the Palaeocene and three, III, IV and V, in the Eocene. Biostratigraphic Unit IV of the Rakhi Nala section is represented in the Zao River section by at least 332 ft., and Unit V by 3743 ft. The Units in the two sections have almost identical ostracod faunas. Biostratigraphic Unit IV of the Rakhi Nala is also represented in the Shpalai Khwara section by at least 320 ft.

The Equations of Correlation of biostratigraphic Unit V between the Rakhi Nala and Zao River sections have been calculated by means of ostracod species common to the two sections. From these two equations any point in one section can easily be correlated with the corresponding point in the other section or vice versa. (see Fig. 6). The standard error of estimate for the two equations has also been calculated. Since only the upper part of biostratigraphic Unit IV in the Zao River section has yielded ostracods, only this part of the unit can be correlated with any certainty.

Eames' lithological units for the southern Sulaiman Range (Rakhi Nala and Zinda Pir) extend into the northern part of the Sulaiman Range (Zao River and Shpalai Khwara). This is particularly true for sediments from the Shales with Alabaster (upper Lower Eocene) to the upper part of the Upper Chocolate Clays (upper Eocene). Sediments below the upper part of the Shales with Alabaster of the Shpalai Khwara section are unfossiliferous except for a few horizons containing poorly preserved pelagic foraminifera. These are 12,450 ft. thick and are probably equivalent to Eames' Upper Rakhi Gaj Shales, Green and Nodular Shales, Rubbly Limestones and lower part of the Shales with Alabaster. In the Zao River section sediments below the upper part of the Shales with Alabaster are undifferentiated and are probably unfossiliferous. This suggests that environmental conditions in the northern Sulaiman Range during most of the Early Eocene were not suitable for abundant marine life.

The faunal breaks in the sections studied do not always coincide with Eames' lithological subdivisions. For example, the Upper Rakhi Gaj Shales, Green and Nodular Shales and Rubbly Limestones have a similar ostracod fauna and are regarded as one ostracod biostratigraphic unit. Another example is in the Kirthar Formation where a new fauna appears before a change in lithology. This occurs in the uppermost part of the Lower Chocolate Clays (i.e. just below the White Marl Band). Most of the species range from the uppermost part of the Lower Chocolate Clays to the lower part of the Upper Chocolate Clays, although the White Marl Band lies in between.

The Palaeocene/Lower Eocene boundary in the Rakhi Nala section has been drawn at the base of the *Nummulites irregularis* Limestone of Eames and Nagappa.

(Bayliss, however, identified this as *Nummulites crasseornata* (Henrici) form B.) This is in agreement with Eames, Bayliss and Latif. The ostracod faunal assemblages below and above the *irregularis* Limestone are completely different and have no species in common. These assemblages have been included in ostracod biostratigraphic Units II and III respectively. The Palaeocene and Lower Eocene boundary in fact has been placed between these two biostratigraphic units. The ranges of ostracod species found in the two biostratigraphic units are shown in Appendix 2.

The Shales below the *irregularis* Limestone have a very rich assemblage of pelagic Foraminifera and have been assigned to the *Globrotalia rex* Zone by Latif. Dr. Banner, lately of the British Petroleum Co. Ltd., who very kindly examined these samples, considers them to be of the high *Globorotalia rex* Zone with derived Lower/Middle Palaeocene pelagic Foraminifera.

The Lower/Middle Eocene boundary in the Rakhi Nala, Zao River and Shpalai Khwara sections has been placed at the base of the Platy Limestone. This is in conformity with Eames, who examined the Rakhi Nala and Zinda Pir sections of the Sulaiman Range. Bayliss and Latif, who worked on the Rakhi Nala section, however, have drawn the boundary in the uppermost part of the Lower Chocolate Clays (i.e. below sample 3498). The Platy Limestone serves as an important horizon marker in the region. The Lower/Middle Eocene boundary lies between ostracod biostratigraphic Units IV and V, which have very different ostracod assemblages. Except for *Alocopocythere transcendens* sp. nov., none of the Lower Eocene ostracod species survive into the Middle Eocene.

The Middle/Upper Eocene boundary in the Rakhi Nala and Zao River sections has been placed between the lower and upper parts of the Upper Chocolate Clays. The upper part of the Upper Chocolate Clays contains the genus *Pellatispira*, which is of Upper Eocene age. In the Rakhi Nala section the boundary is taken arbitrarily between samples 3627 and 3628. This is approximately the same level as drawn by Eames (1952), who recorded the first appearance of *Pellatispira* just above this horizon in the section. Bayliss, however, recorded *Pellatispira* only from one horizon (sample 3657) in the *Pellatispira* Beds. Latif has placed the boundary in the middle of his *Chiloguembelina* aff. *martini* Zone (i.e. above sample 3618). In the Zao River section sample 24161 contains specimens of *Pellatispira* in abundance. These have been assigned to *Pellatispira orbitoidea* (Povale) *sensu* Rao 1941 by Dr. C. G. Adams of the British Museum (personal communication), who very kindly examined these specimens. According to Dr. Adams these fall midway between *P. orbitoidea* and *P. madaraszi* var. *indica*. The Middle/Upper Eocene boundary in the Zao River section can, therefore, safely be placed below sample 24161.

The Middle and Upper Eocene ostracod fauna of the Rakhi Nala and Zao River sections is of changing suite and has been included in ostracod biostratigraphic Unit V. It does not show any sharp break between the Middle and the Upper Eocene. Some species are restricted to the Middle Eocene, but others range from the Middle to the Upper Eocene. Some of the important species restricted to the Middle Eocene are : *Actinocythereis* ? *quasibathonica* sp. nov., " *Anommatocythere* " *confirmata* sp. nov., *Echinocythereis* (*Scelidocythereis*) *rasilis* sp. nov., *Cytheropteron* sp.C, *Gyrocythere exaggerata* sp. nov., *Trachyleberis* (*Trachyleberis*) *bimammillata*

sp. nov. Some of the common species which range from the Middle to the Upper Eocene are : *Alocopocythere transversa* sp. nov., *Bairdoppilata* sp.A, *Cytherelloidea* cf. *C. costatruncata* Lubimova and Mohan, *Cytheromorpha* sp.A, *Cytheropteron* sp.D, *Paijenborchella* sp.C, *Patagonacythere* ? *nidulus* sp. nov., *Pterygocythereis* (*Pterygocythere*) sp.A and *Stigmatocythere lumaria* sp. nov. (A complete list of these species is given in Tables 4 & 5).

VI. APPENDICES

Appendix 1

Sor Range Lease 58, measured section at locality 460.
Section measured by J. A. Reinemund.

Thickness (feet)	Description of Unit	Sample No.
10+	Claystone, grey	
42	Conglomerate containing limestone and chert pebbles, cobbles, boulders as much as 8 in. across ; matrix of medium grained, yellowish brown sandstone forms about 20% of rock.	
42	Concealed by talus	
18	Claystone, medium grey, not fissile, semiplastic, containing scattered fossils. Calcareous nodules at top ; silty and carbonaceous in lower part.	460a (near top)
2–3	Sandstone, very fine grained to silty brownish-grey, imperfect and irregular bedding, contains carbonized plant fragments and vertical root moulds.	
24	Claystone, dark olive grey, not fissile, silty in upper few feet and lower few feet ; contains irregular coal layers as much as 4 in. thick in lower 2 ft.	460b (6–8 above bottom) 460c (3–4 feet above bottom)
7½	Sandstone, fine to very fine grained, light brownish grey, mostly even beds 2–8 in. thick, locally cross-bedded.	460d
2	Siltstone, poorly bedded, carbonaceous, containing very carbonaceous layers as much as ⅛ in. thick in top 2 in.	
1½	Claystone, silty, olive grey, not fissile, containing carbonised plant chips.	
5	Siltstone, brownish grey, imperfect beds, cross laminated.	
45	Claystone, silty at top, olive grey not fissile.	460e (5–6 feet above bottom) 460f (1–2 feet above bottom)

Thickness (feet)	Description of Unit	Sample No.
8	Claystone, containing profuse white calcareous concretions.	
2	Claystone, olive grey, fissile, grading down into siltstone, yellowish-brown, hard, fossiliferous.	460g (Channel sample)
50+	Claystone, slightly fissile, olive grey.	460h–o

Appendix 2

List of ostracod species common to the Rakhi Nala and Zao River Sections

No.	Species	Rakhi Nala Base	Rakhi Nala Top	Zao River Base	Zao River Top
5	*" Anommatocythere " laqueta* sp. nov.	4045	5223	252	
13	*Phalcocythere dissenta* sp. nov.	4968	5195	252	
14	*Stigmatocythere obliqua* sp. nov.	4815	5373	252	294
21	*Cytherella* sp.C	5112	5195	252	
35	*Neocyprideis* ? sp.G	4815	5373	252	294
36	*Neocyprideis* sp.C	5373		252	294
44	*Xestoleberis* sp.C	4919	5208	252	294
45	*Xestoleberis* sp.D	5112	5195	252	
46	*Xestoleberis* sp.E	4815	5208	252	
48	*Genus C* sp.1	4687	5304	252	
49	*Genus C* sp.2	4687	5373	252	
50	*Bairdia* sp.C	3682+	4815	252	
51	*Bairdia* sp.D	3995	5195	252	
52	*Cytherella* sp.B	2687+	5223	252	
53	*Pontocyprella* sp.B	5023	5304	252	
54	*Pontocyprella* sp.C	4687	5208	252	
1	*Actinocythereis* ? *quasibathonica* sp. nov.	6369	6524	1872	1994
2	*Alocopocythere transcendens* sp. nov.	3215+	6488	650+	1948
3a	*A. transversa* sp. nov. Morphotype A	6575	6706	2032	2190
3b	*A. transversa* sp. nov. Morphotype B	6589+	6690	3384+	
3c	*A. transversa* sp. nov. Morphotype C	6764	7014	2190	3230
3d	*A. transversa* sp. nov. Morphotype D	6839	7–37	2504	3230
3e	*A. transversa* sp. nov. Morphotype E	6839	7107	2086	3186
3f	*A. transversa* sp. nov. Morphotype F	6943	7037	2504	2808
4	*A. radiata* sp. nov.	7029		2712	
6	*" Anommatocythere " confirmata* sp. nov.	6138	6424	1570	1948
7	*Echinocythereis* (*Scelidocythereis*) *rasilis* sp. nov.	6138	6463	1570	1986
8	*E.* (*S.*) *multibullata* sp. nov.	6531	6589+	1994	3095
9	*Gyrocythere exaggerata* sp. nov.	6401	6515	1570	1948
10	*Hermanites palmatus* sp. nov.	6401	6488	994	2060

No.	Species	Rakhi Nala		Zao River	
		Base	Top	Base	Top
11	*Hermanites scopus* sp. nov.	6138	6488	1766	1872
12	*Patagonacythere* ? *nidulus* sp. nov.	6575	7118	2032	3384
15a	*Stigmatocythere lumaria* sp. nov. Morphotype A	6531	7121	2060	3384
15b	*S. lumaria* sp. nov. Morphotype B	6839	7029	2712	
16	*Trachyleberis* (*Trachyleberis*) *bimammillata* sp. nov.	6369	6463	1872	1948
17	*T.* (*Acanthocythereis*) *postcornis* sp. nov.	6121	6138	994	1766
18	*T.* (*Acanthocythereis*) *decoris* sp. nov.	6200	7124	1994	3384
19	*Aglaiocypris* sp.B	6415		2190	3040+
20	*Bairdoppilata* sp.A	6138	7014	794	3186
22	*Cytherella* sp.E	6121	6401	994	2032
23	*Cytherella* sp.F	6424	6985	994	3040
24	*Cytherella* sp.G	6121	6985	994	3095
25	*Cytherelloidea* cf. *C. costatruncata* Lubimova and Mohan	6121	7001	994	3095
26	*Cytherelloidea* sp.E	6985	7029	3000	3095
27	*Cytherelloidea* sp.F	6121	7124	994	3095
28	*Cytheromorpha* sp.A	6138	6974	994	2904
29	*Cytheropteron* sp.C	6121	6606	994	1872
30	*Cytheropteron* sp.D	6121+	7029	2086+	3095
31	*Krithe* sp.C	6121	7096	1766	3095
32	*Krithe* sp.D	6311	7107	1710	3140
33	*Krithe* sp.E	6138	7014	1710	3140
34	*Krithe* sp.F	6931	6985	2504	2760
37	*Neocyprideis* ? sp.D	7096	7124	3344	3450
38	*Paijenborchella* sp.C	6121	7096	794	3095
39	*Paijenborchella* sp.E	6311	7096	1900	2712
40	*Paijenborchella* sp.F	7114	7124	3186	3450
41	*Propontocypris* sp.A	6266	6564	1766	2266
42	*Pterygocythereis* (*Pterygocythere*) sp.A	6575	6985	2060	3130
43	*Schizocythere* sp.B	6138	6524	994	1994
47	*Xestoleberis* sp.G	6138	6931	1766	3130

+ Points omitted from computation.

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PLATE 1

Actinocythereis ? quasibathonica sp. nov.

FIGS. 1, 10. Dorsal and right views, carapace male, × 70. Paratype, Io. 4260. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

FIGS. 2, 3, 11, 12. Dorsal, ventral, left and right views, carapace female, × 70. Holotype, Io. 4311. Upper Chocolate Clays (lower part), sample 3611, Rakhi Nala.

FIG. 6. Dorsal view of hinge, left valve male, × 230. Paratype, Io. 3101. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

FIGS. 7, 13. 7, dorsal view of hinge × 230 ; 13, anterior radial pore canals × 230. Right valve male. Paratype, Io. 3100. Upper Chocolate Clays, sample 3611, Rakhi Nala.

Alocopocythere transcendens gen. et sp. nov.

FIGS. 4, 5, 8, 9. Dorsal, ventral, right and left views, carapace male, × 90. Paratype, Io. 3104. Upper Chocolate Clays (lower part), sample 3607, Rakhi Nala.

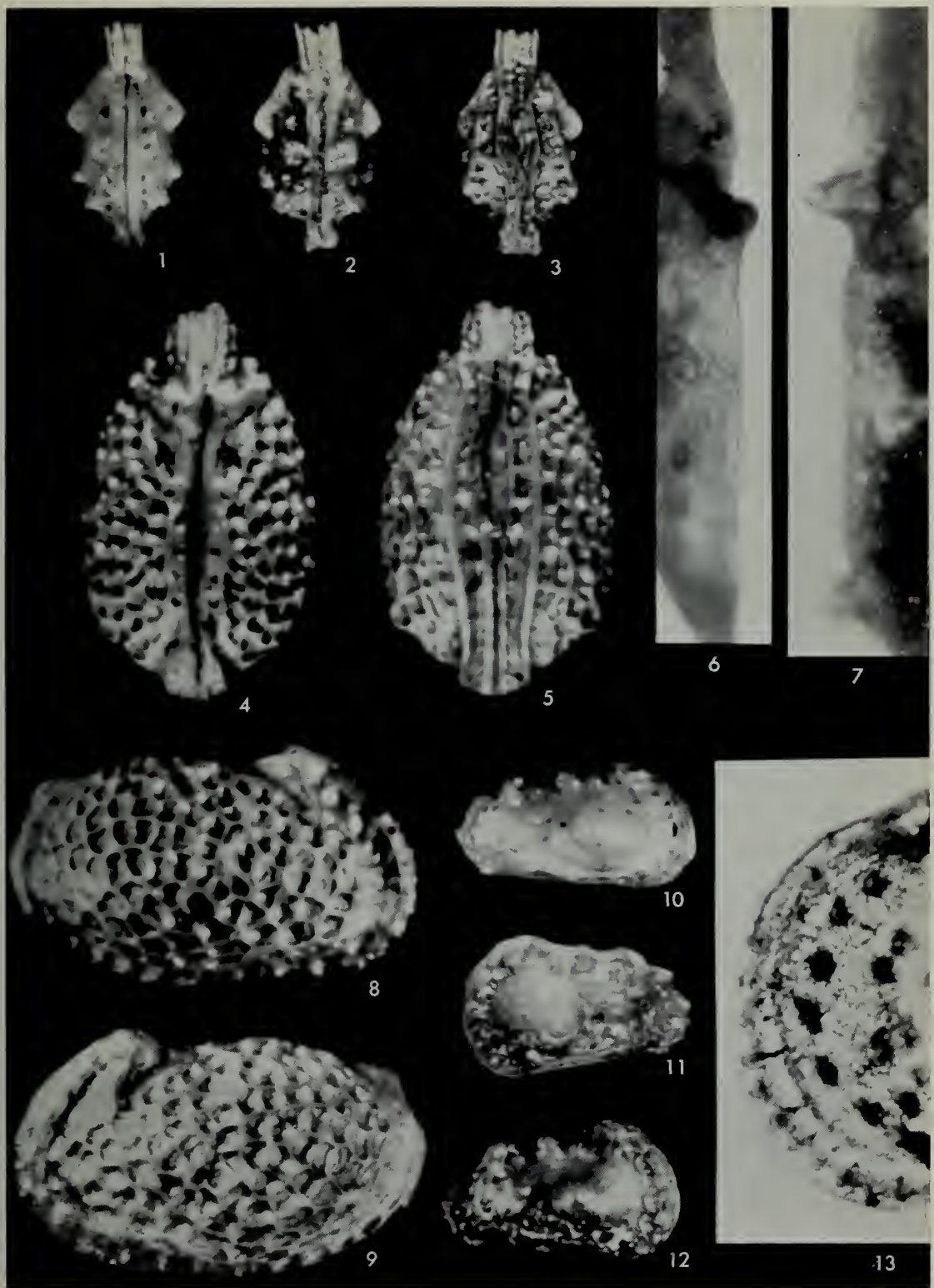
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PLATE 2

Alocopocythere transcendens gen. et sp. nov.

FIGS. 1, 6. External and dorsal views, left valve female, × 90. Holotype, Io. 4315. Upper Chocolate Clays (lower part), sample 24148, Zao River.

FIG. 2. Muscle scars (× 200) showing four adductors and an oval frontal scar. Right valve male (broken), × 90. Paratype, Io. 3106. Upper Chocolate Clays, sample 24151, Zao River.

FIG. 3. Anterior radial pore canals × 128. Left valve female. Paratype, Io. 4261. Upper Chocolate Clays (lower part), sample 24148, Zao River.

FIGS. 4, 7. External and dorsal views, right valve female, × 90. Paratype, Io. 3105. Upper Chocolate Clays (lower part), sample 24148, Zao River.

Alocopocythere rupina sp. nov.

FIGS. 5, 8–10. Right, left, dorsal and ventral views, carapace male × 90. Holotype, Io. 4314. Gorge Beds, sample 3111, Rakhi Nala.

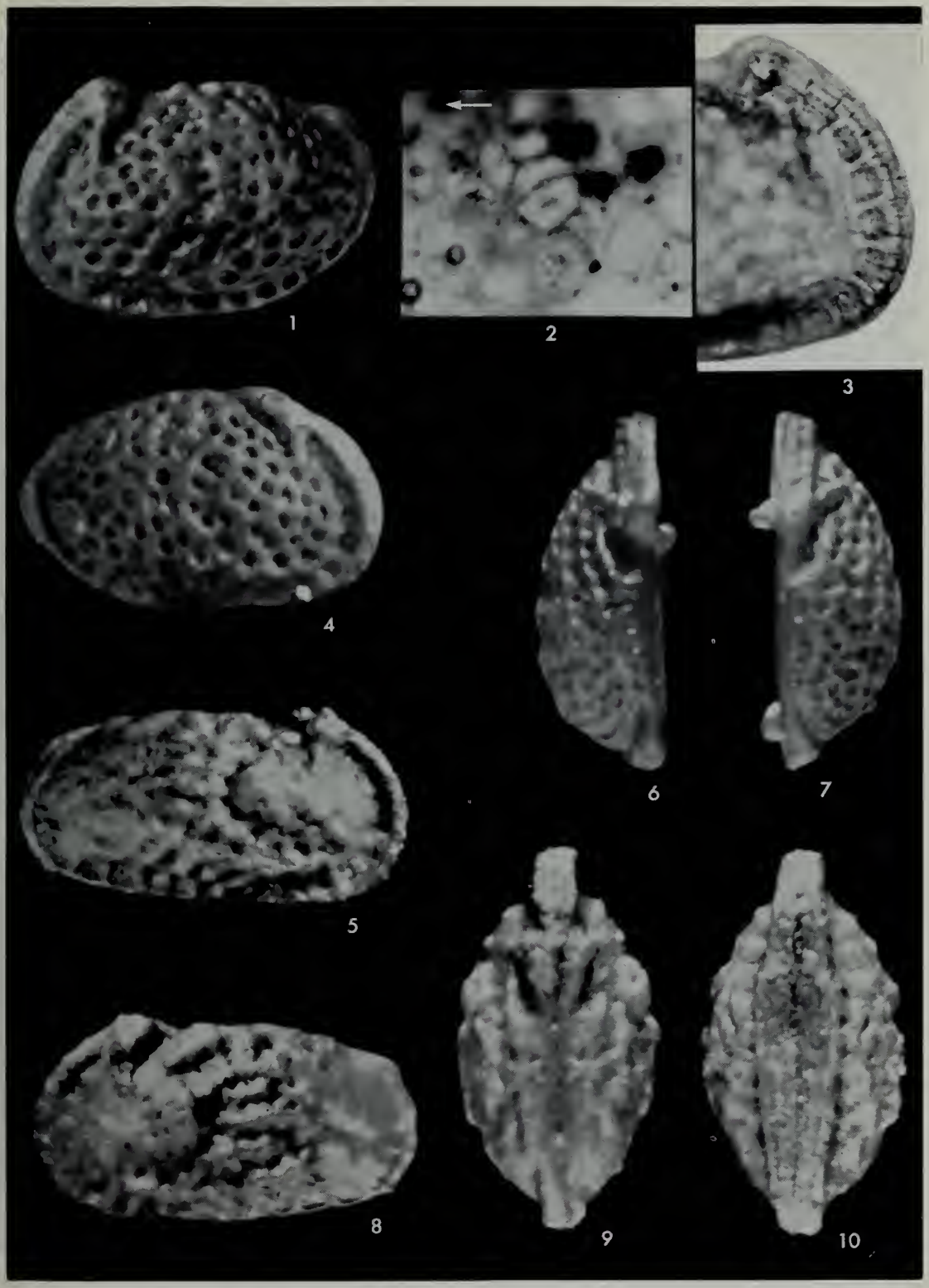
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PLATE 3

Alocopocythere rupina sp. nov.

FIGS. 1–4. Left, right, dorsal and ventral views, carapace female, × 90. Paratype, Io. 4262. Gorge Beds, sample 3111, Rakhi Nala.

Alocopocythere abstracta sp. nov.

FIGS. 5–8. Left, dorsal, ventral and right views, carapace male, × 90. Paratype, Io. 4263. Upper Rakhi Gaj Shales, sample 3163, Rakhi Nala.

FIGS. 9–11. Right, dorsal and ventral views, carapace female × 90. Holotype, Io. 4312. Upper Rakhi Gaj Shales, sample 3163, Rakhi Nala.

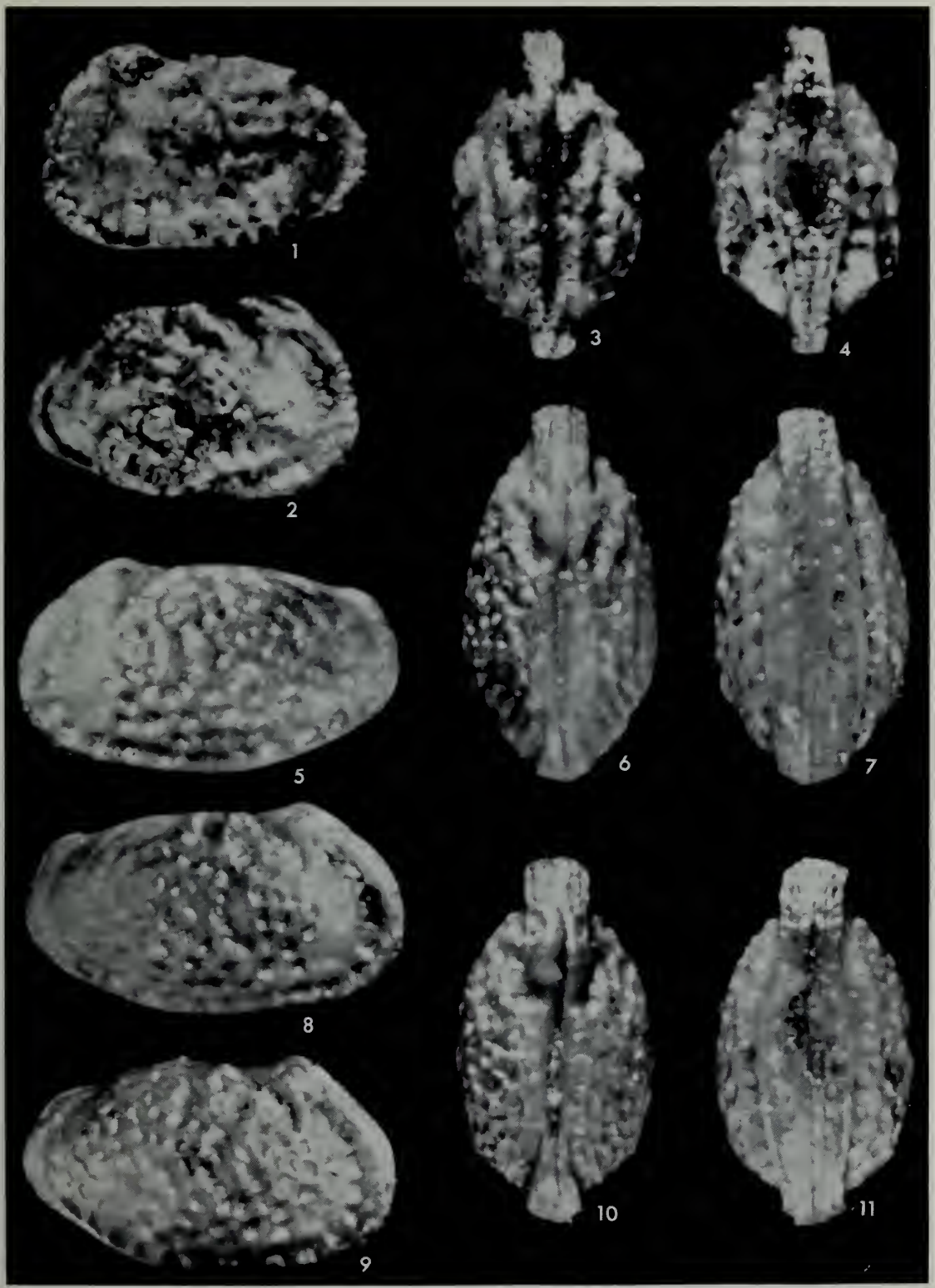
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PLATE 4

Alocopocythere abstracta sp. nov.

FIG. 1. Left view, carapace female, × 90. Holotype, Io. 4312. Upper Rakhi Gaj Shales, sample 3163, Rakhi Nala.

Alocopocythere coarctata sp. nov.

FIGS. 2–5. Dorsal, ventral, left and right views, carapace male, × 90. Paratype, Io. 4264. Shales with Alabaster, sample 3448, Rakhi Nala.

FIGS. 6–9. Dorsal, ventral, left and right views, carapace female, × 90. Holotype, Io. 4313. Shales with Alabaster, sample 3458, Rakhi Nala.

Alocopocythere longilinea sp. nov.

FIGS. 10–13. Dorsal, right, ventral and left views, carapace male, × 90. Holotype, Io. 4318 Shales with Alabaster, sample 3443, Rakhi Nala.

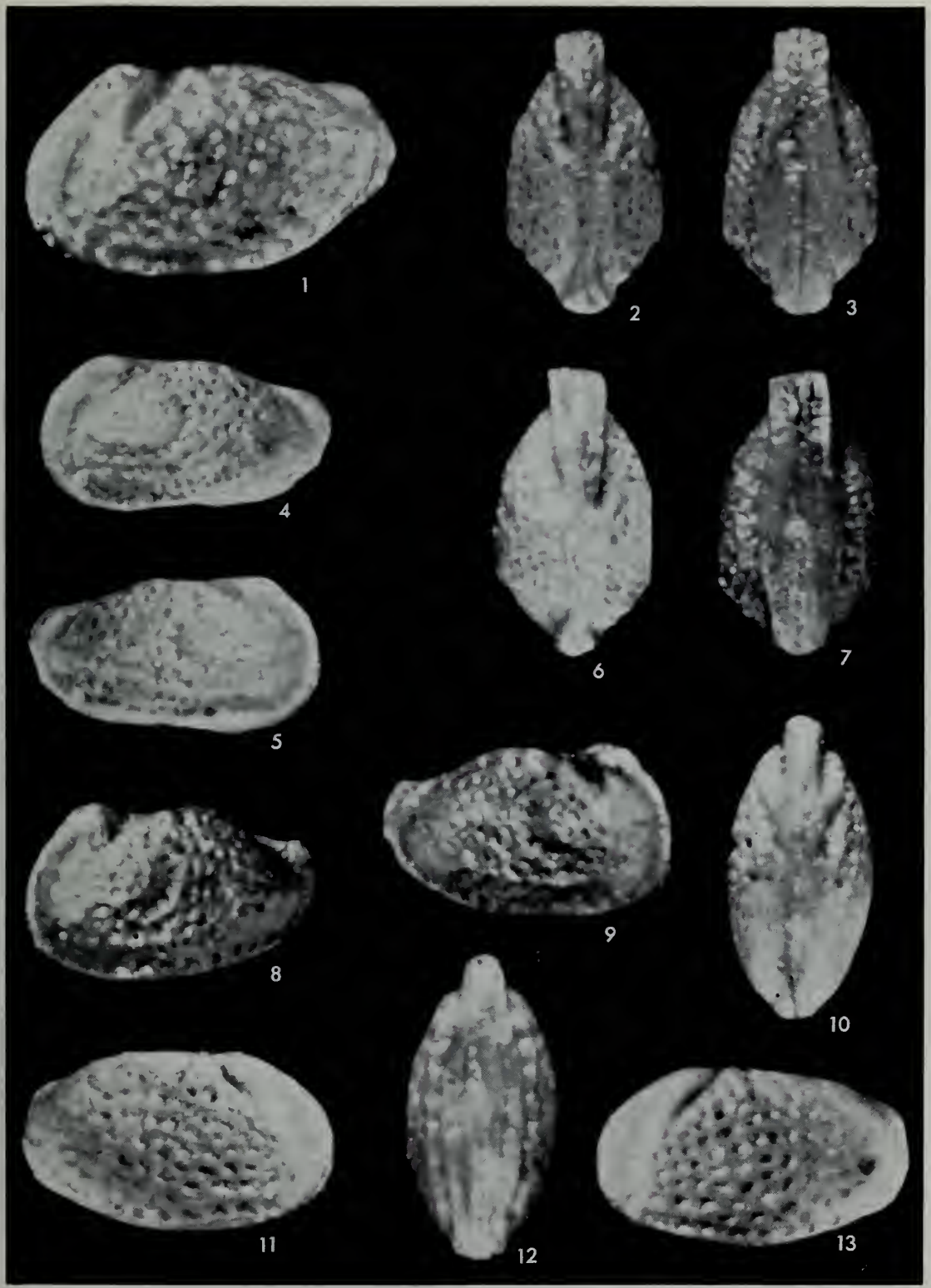
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PLATE 5

Alocopocythere longilinea sp. nov.

FIGS. 1–3, 6. Left, right, dorsal and ventral views, carapace female, × 90. Paratype, Io. 4265. Shales with Alabaster, samples 3443, Rakhi Nala.

Alocopocythere transversa sp. nov.

Morphotype A

FIGS. 4, 5, 7, 9. Dorsal, ventral, left and right views, carapace male, × 90. Paratype, Io. 4266. Upper Chocolate Clays (lower part), sample 24155, Zao River.

FIGS. 8, 10. Left and right views, carapace female, × 90. Holotype, Io.4316. Upper Chocolate Clays (lower part), sample 24155, Zao River.

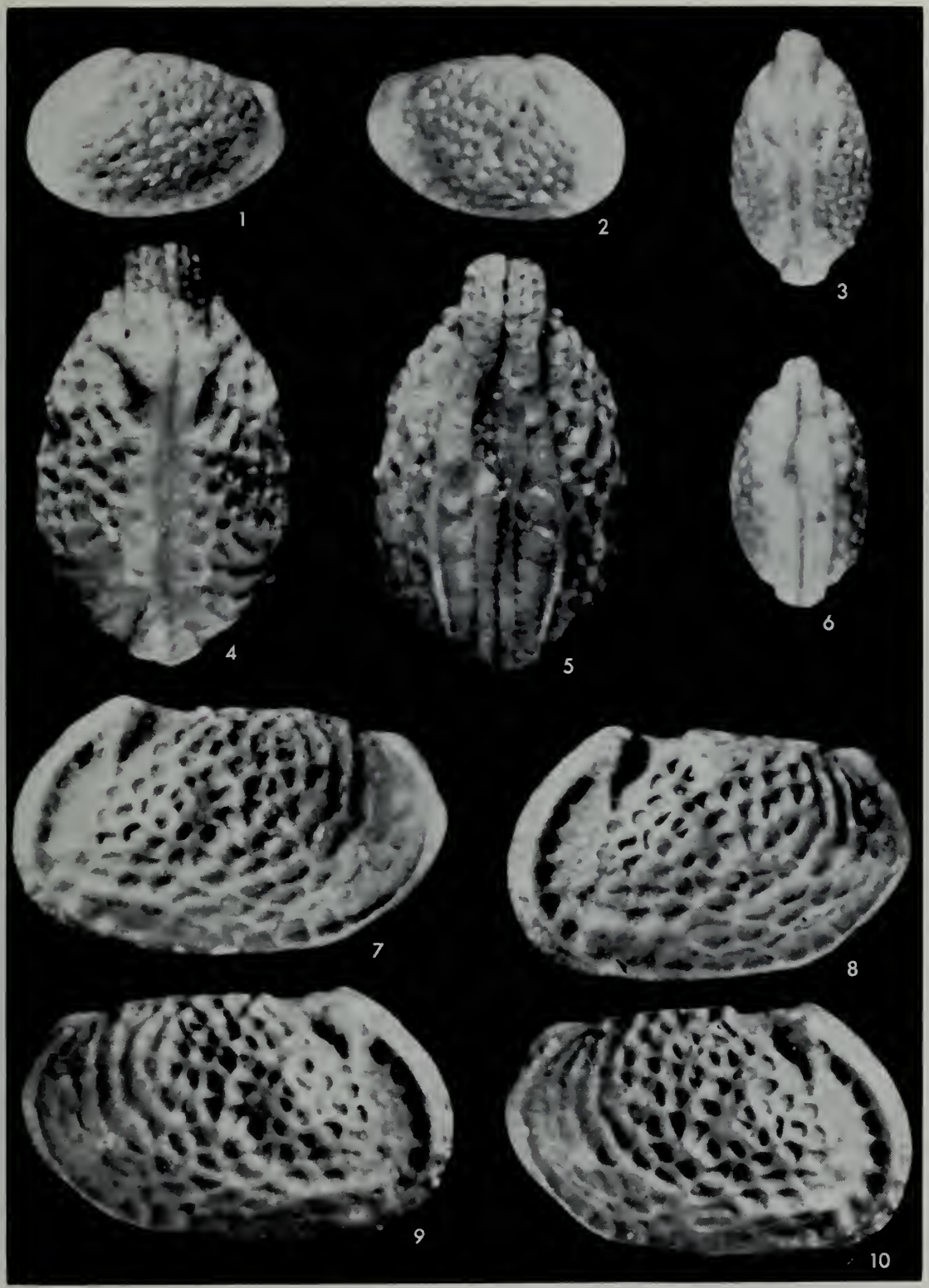
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PLATE 6

Alocopocythere transversa sp. nov.

Morphotype A

FIGS. 1, 2. Dorsal and ventral views, carapace female, × 90. Holotype, Io. 4316. Upper Chocolate Clays (lower part), sample 24155, Zao River.

FIGS. 3, 4. Dorsal and internal views, right valve male, × 90. Paratype Io. 3107. Upper Chocolate Clays (lower part), sample 3625, Rakhi Nala.

Morphotype C

FIGS. 5, 7. Left and right views, carapace male, × 90. Paratype, Io. 4267. Upper Chocolate Clays (upper part), sample 24183, Zao River.

FIGS. 6, 8. Left and right views, carapace female, × 90. Paratype, Io. 4268. Upper Chocolate Clays (upper part), sample 24183, Zao River.

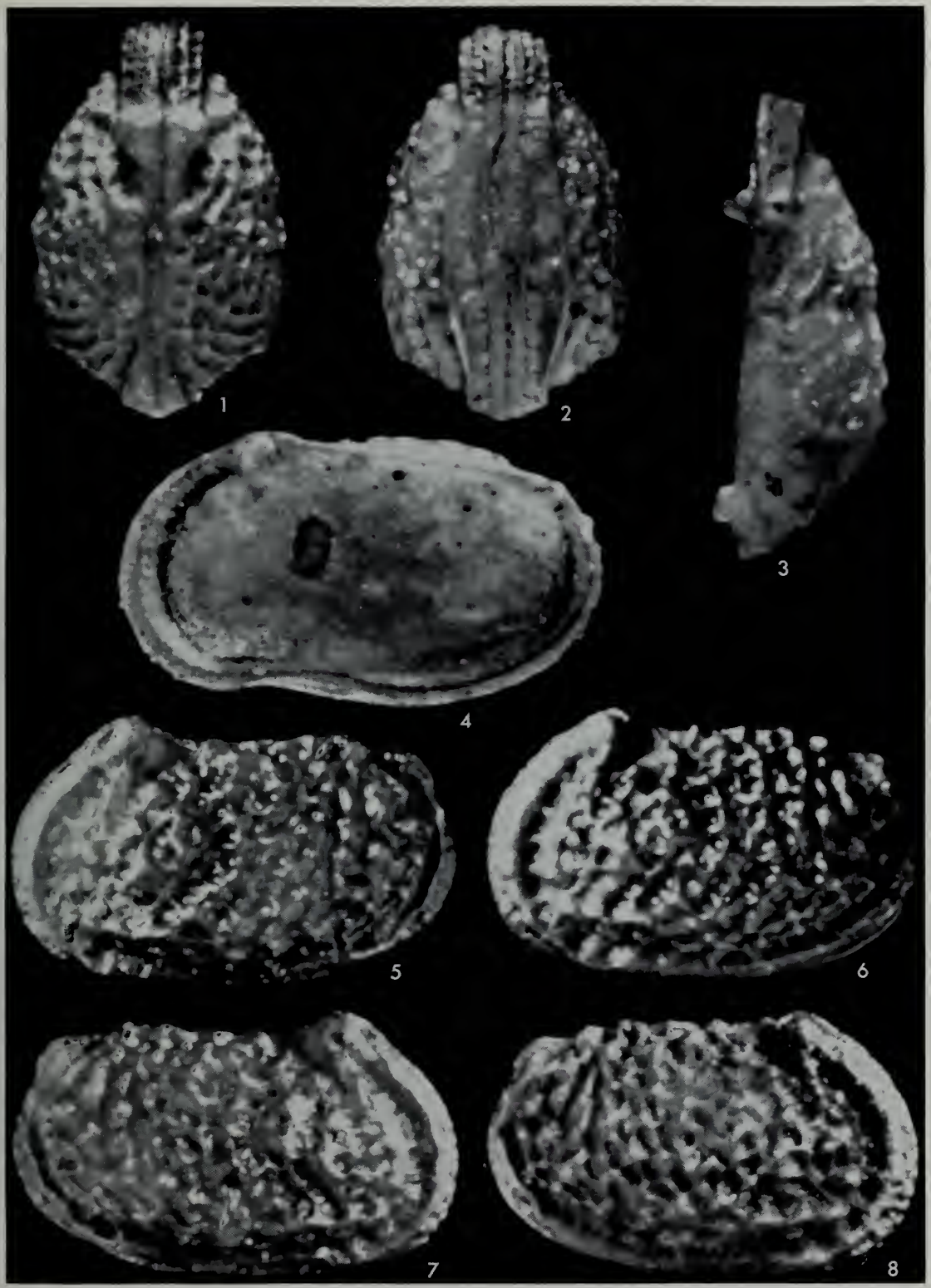
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PLATE 7

Alocopocythere transversa sp. nov.

Morphotype C

FIGS. 1, 2. Dorsal and ventral views, carapace male, × 90. Paratype, Io. 4267. Upper Chocolate Clays (upper part), sample 24183, Zao River.

FIGS. 3, 4. Dorsal and ventral views, carapace female, × 90. Paratype, Io. 4268. Upper Chocolate Clays (upper part), sample 24183, Zao River.

Morphotype E

FIGS. 5–7. Dorsal, ventral and left views, carapace male, × 90. Paratype, Io. 3110. Upper Chocolate Clays (upper part), sample 24175, Zao River.

FIG. 8. Left view, carapace female, × 90. Paratype, Io. 3111. Upper Chocolate Clays (upper part), sample 24175, Zao River.

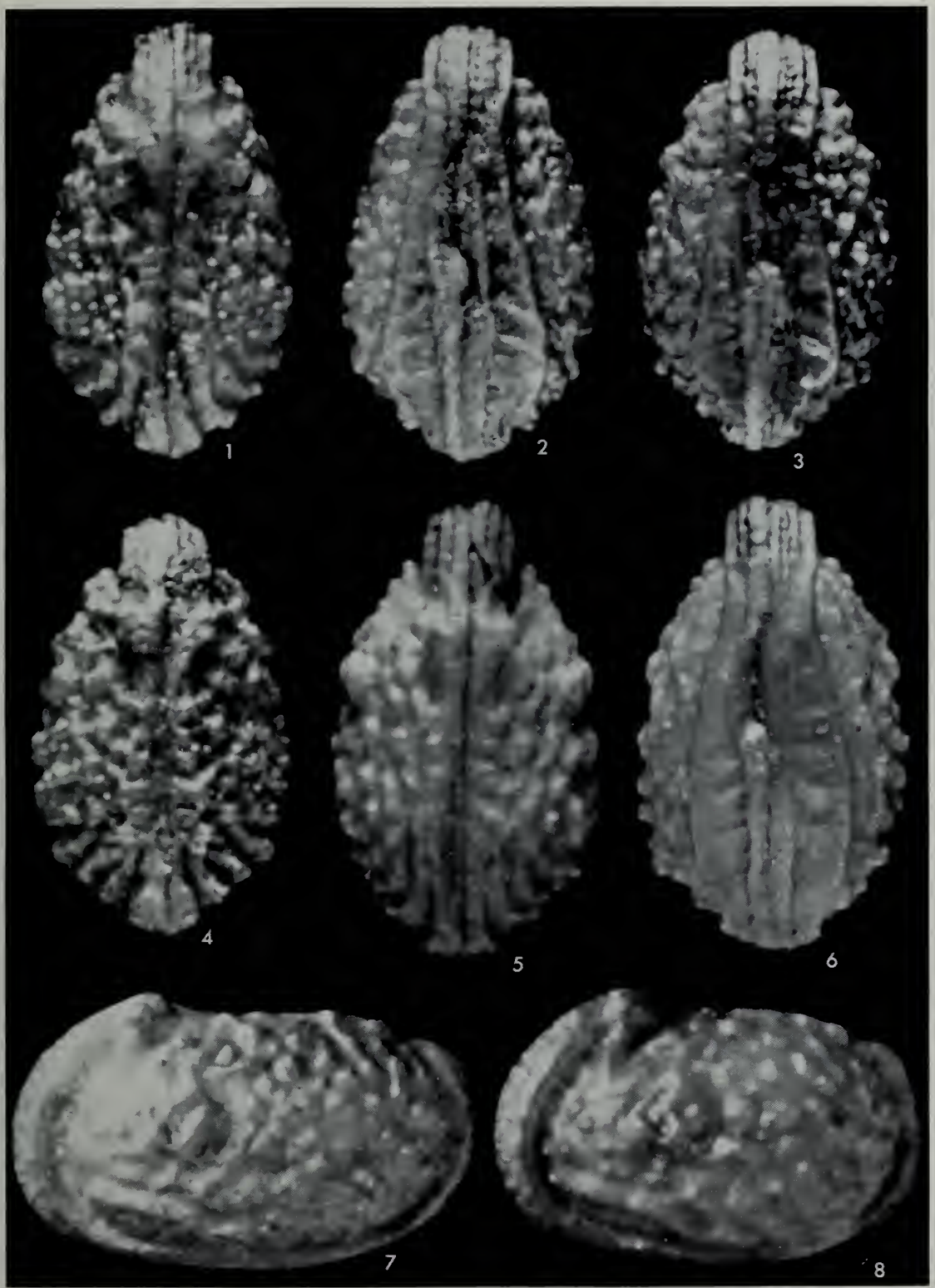
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PLATE 8

Alocopocythere transversa sp. nov.

Morphotype E

FIG. 1. Right view, carapace male, × 90. Paratype, Io. 3110. Upper Chocolate Clays (Upper part), sample 24175. Zao River.

FIGS. 2, 3, 5. Right, dorsal and ventral views, carapace female, × 90. Paratype, Io. 3111 Upper Chocolate Clays (upper part), sample 24175, Zao River.

Morphotype C

FIG. 4. Muscle scars (× 200) showing four adductor, an oval frontal and two mandibular scars. Right valve male (broken). Paratype, Io. 4269. Upper Chocolate Clays (upper part), sample 24174, Zao River.

Morphotype F

FIGS. 6, 8. Left and right views, carapace male, × 90. Paratype, Io. 3109. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

FIGS. 7, 9. Left and right views, carapace female, × 90. Paratype, Io. 3108. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

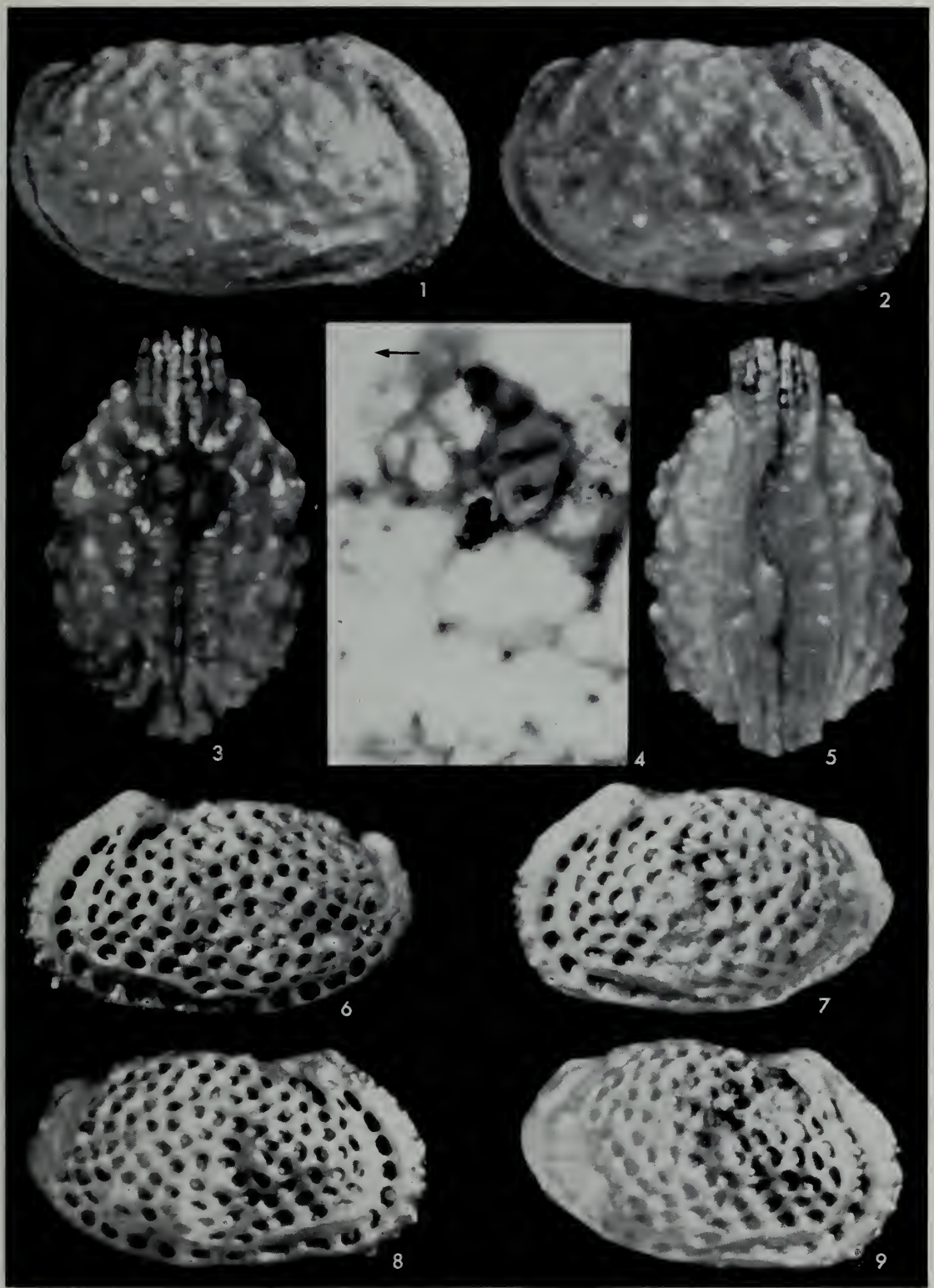
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PLATE 9

Alocopocythere transversa sp. nov.

Morphotype F

FIGS. 1, 2. Dorsal and ventral views, carapace male, × 90. Paratype, Io. 3109. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

FIGS. 3, 5. Dorsal and ventral views, carapace female, × 90. Paratype, Io. 3108. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

FIG. 4. Internal view to show radial pore canals, right valve female, × 108. Paratype, Io. 3112. Upper Chocolate Clays (upper part), sample 24174, Zao River.

Alocopocythere radiata sp. nov.

FIGS. 6, 8. Left and right views, carapace male, × 90. Holotype, Io. 4317. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

FIGS. 7, 9. Left and right views, carapace female, × 90. Paratype, Io. 4270. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

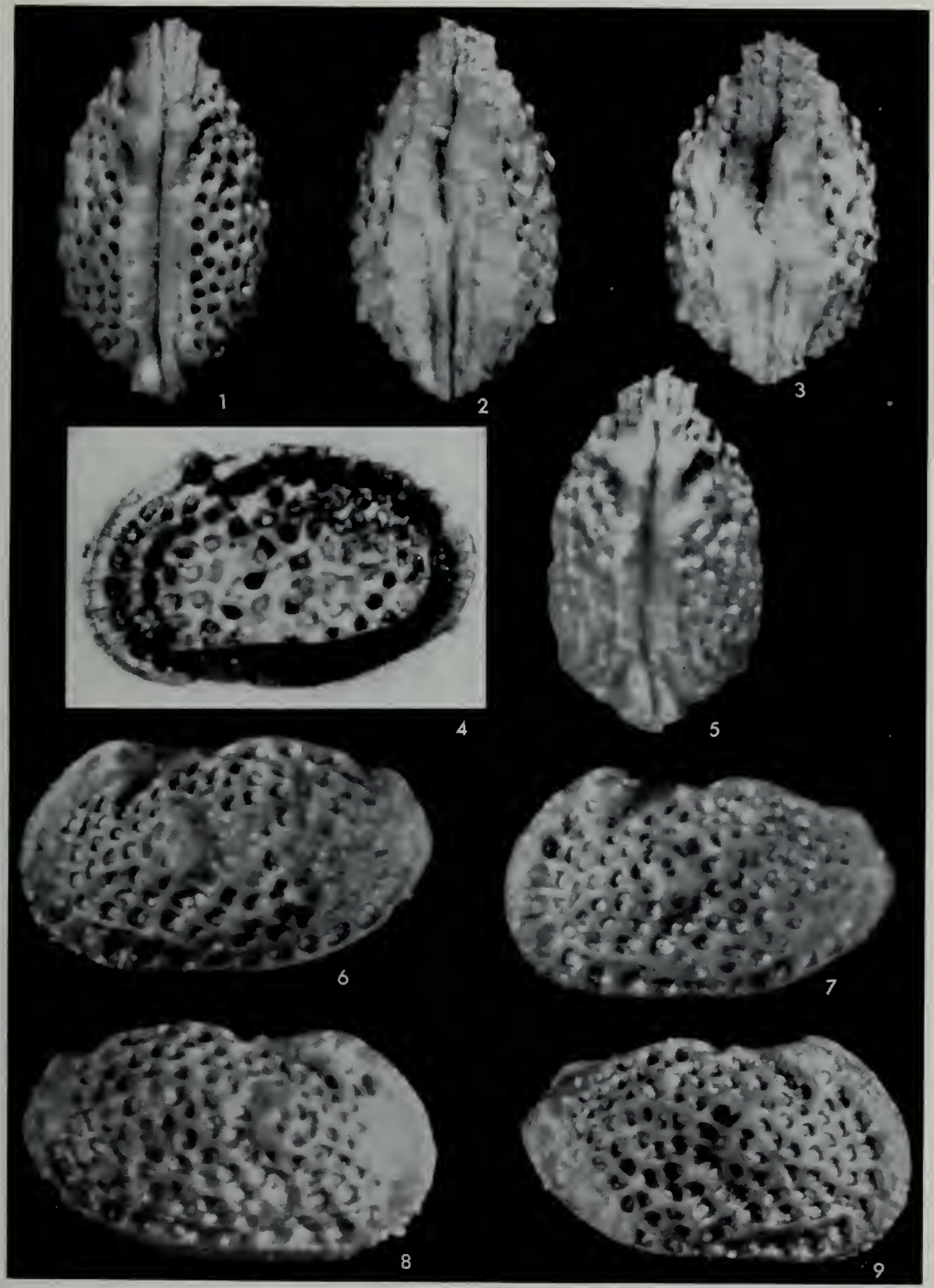
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PLATE 10

Alocopocythere radiata sp. nov.

FIGS. 1, 2. Dorsal and ventral views, carapace male, × 90. Holotype, Io. 4317. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

FIGS. 3, 4. Ventral and dorsal views, carapace female, × 90. Paratype, Io. 4270. Upper Chocolate Clays (upper part), sample 3652, Rakhi Nala.

" Anommatocythere " laqueta sp. nov.

FIGS. 5–7. Right, left and dorsal views, carapace male, × 70. Paratype, Io. 4271. Green and Nodular Shales, sample 3403, Rakhi Nala.

FIGS. 8–10. Left, right and dorsal views, carapace female, × 70. Holotype, Io. 4320. Green and Nodular Shales, sample 3403, Rakhi Nala.

" Anommatocythere " confirmata sp. nov.

FIGS. 11, 12. Right and left views, carapace male, × 70. Holotype, Io. 4319. Upper Chocolate Clays (lower part), sample 3611, Rakhi Nala.

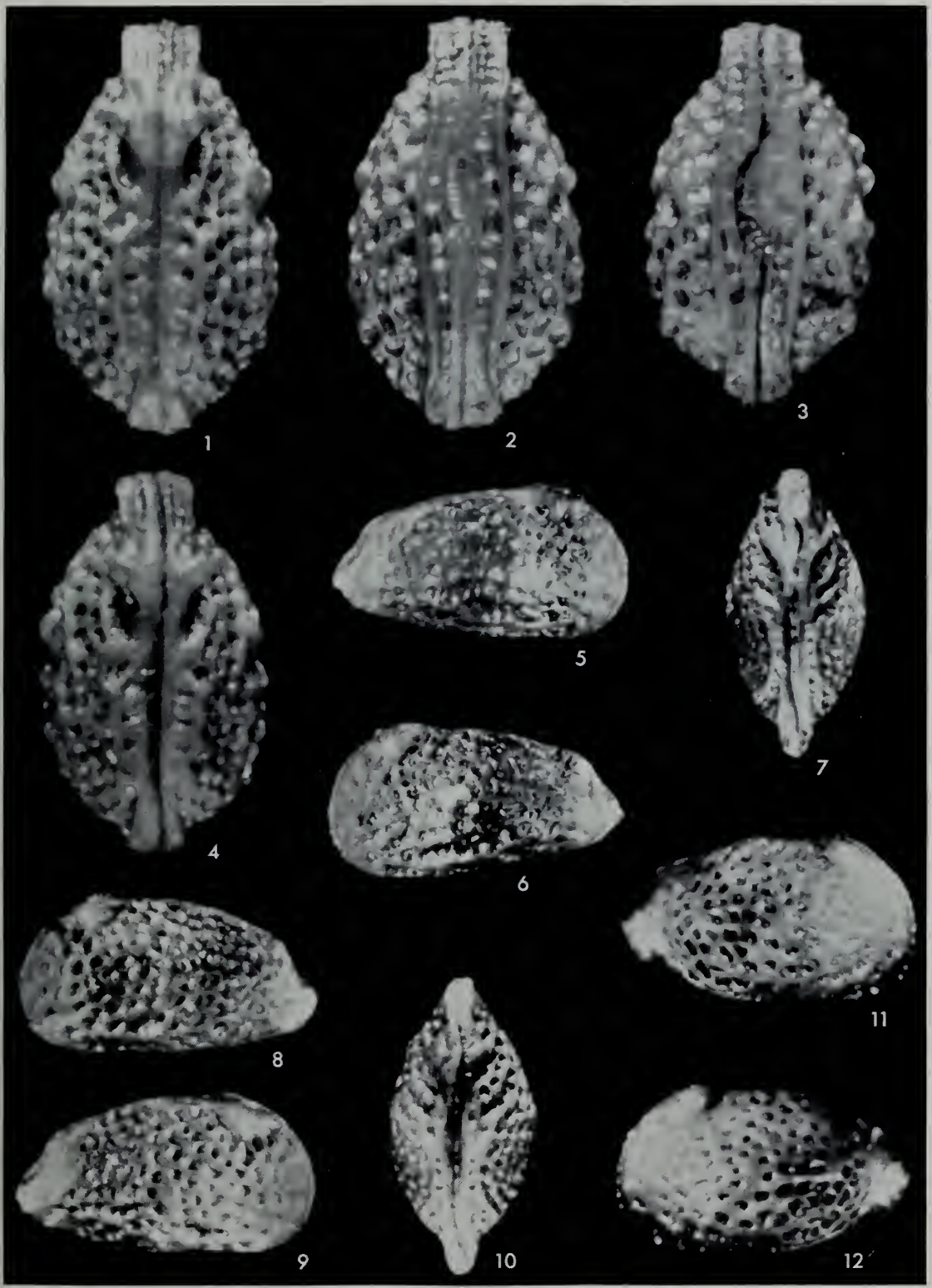
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PLATE 11

" Anommatocythere " confirmata sp. nov.

FIGS. 1, 2. Dorsal and ventral views, carapace male, × 70. Holotype, Io. 4319 Upper Chocolate Clays (lower part), sample 3611, Rakhi Nala.

FIG. 3. Anterior radial pore canals × 232, left valve male. Paratype, Io. 3102. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIGS. 4, 5, 8, 9. Dorsal, ventral, right and left views, carapace female, × 70. Paratype, Io. 4272. Upper Chocolate Clays (lower part), sample 24148, Zao River.

FIGS. 6, 7. Anterior and posterior radial pore canals × 232, right valve male. Paratype, Io. 3103. Upper Chocolate Clays (lower part), sample 24151, Zao River.

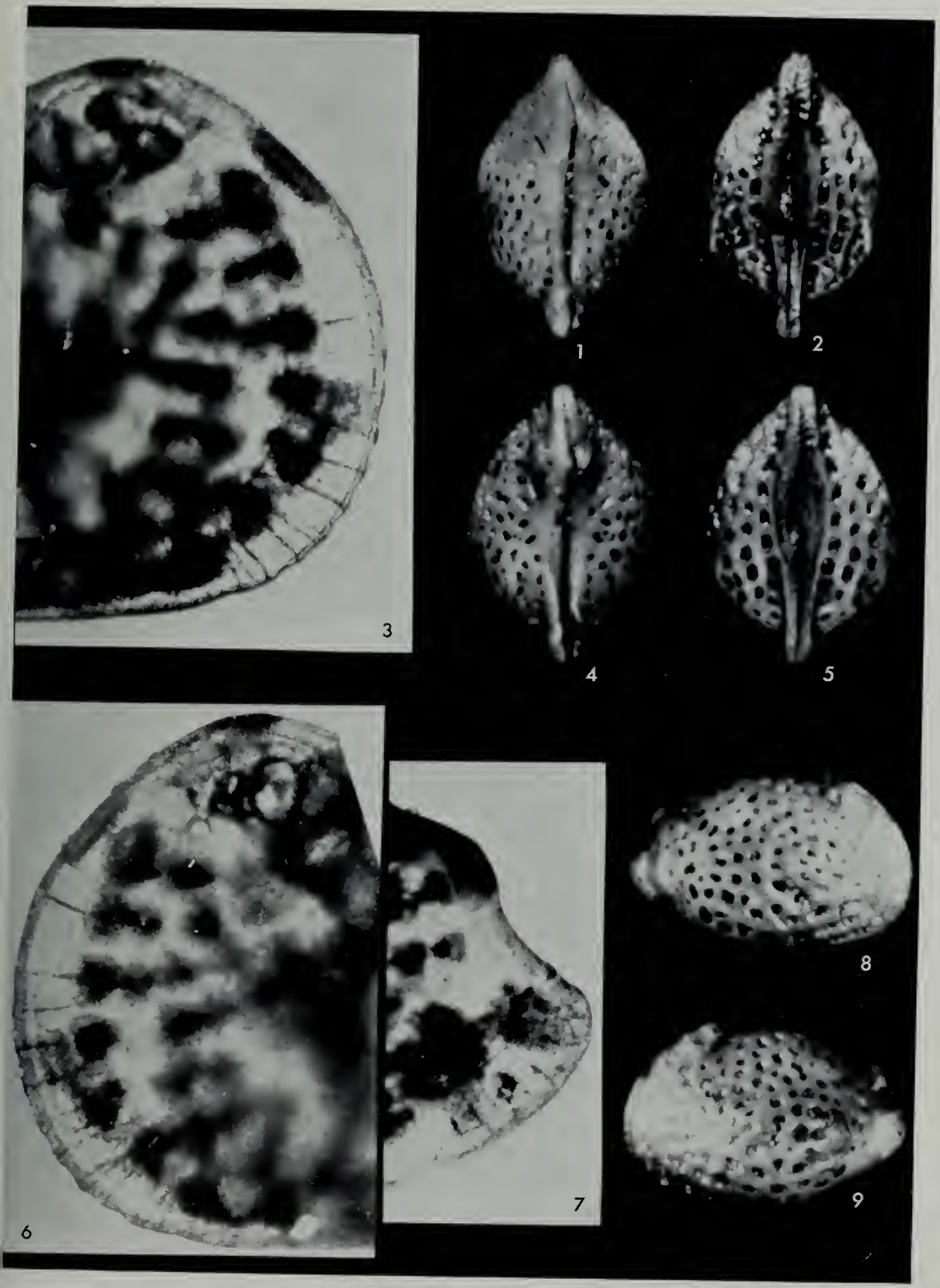
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PLATE 12

" Anommatocythere " confirmata sp. nov.

FIG. 1. Dorsal view of hinge × 183, left valve male. Paratype, Io. 3102. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIG. 2. Dorsal view of hinge × 183, right valve male. Paratype, Io. 3103. Upper Chocolate Clays (lower part), sample 24151, Zao River.

Bradleya ? voraginosa sp. nov.

FIGS. 3, 5, 7, 8. Dorsal left, right and ventral views, carapace male, × 70. Holotype, Io. 4321. Upper Chocolate Clays (upper part), sample 24161, Zao River.

FIGS. 4, 6. 9. Dorsal, right and left views, carapace female, × 70. Paratype, Io. 3115. Upper Chocolate Clays (upper part), sample 24161, Zao River.

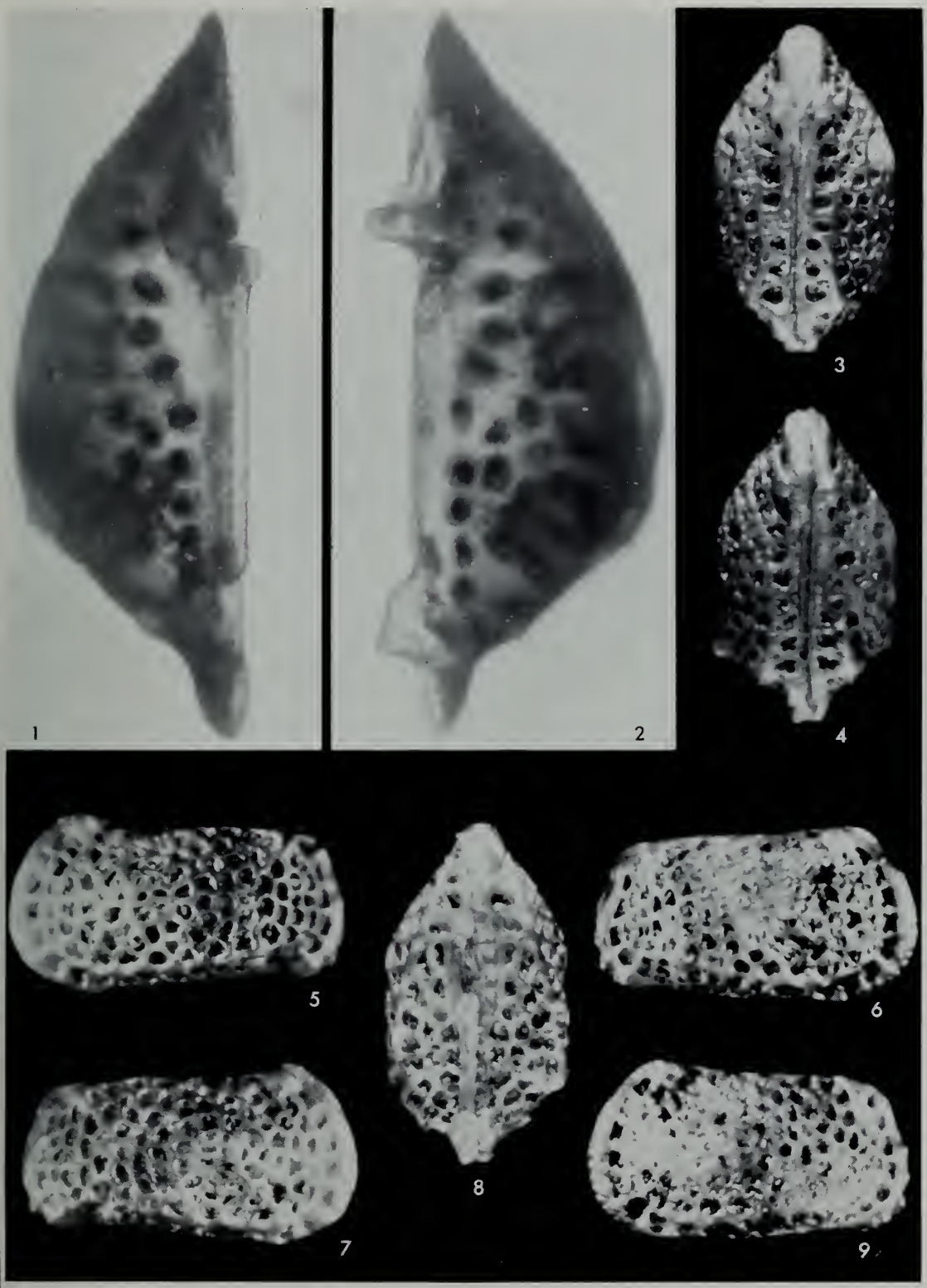
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PLATE 13

Buntonia devexa sp. nov.

FIGS. 1, 3. Left and right views, carapace male, × 70. Paratype, Io. 3113. Gorge Beds, sample 3111, Rakhi Nala.

FIGS. 2, 4, 5. Left, dorsal and right views, carapace female, × 70. Holotype, Io. 4322. Gorge Beds, sample 3111, Rakhi Nala.

Buntonia sp.A

FIGS. 6, 7, 9. Left, right and dorsal views, carapace, × 70. Paratype, Io. 3114. Lower Rakhi Gaj Shales, sample 3133, Rakhi Nala.

Costa (Paracosta) declivis subgen. et sp. nov.

FIGS. 8, 10–12. Left, right, dorsal and ventral views, carapace male, × 68. Holotype, Io. 4325. *Pellatispira* Beds, sample 3662, Rakhi Nala.

FIG. 13. Right view, carapace female, × 68. Paratype, Io. 4273. *Pellatispira* Beds, sample 3662, Rakhi Nala.

FIG. 14. Left view, carapace female, × 68. Paratype, Io. 3116. *Pellatispira* Beds, sample 3662, Rakhi Nala.

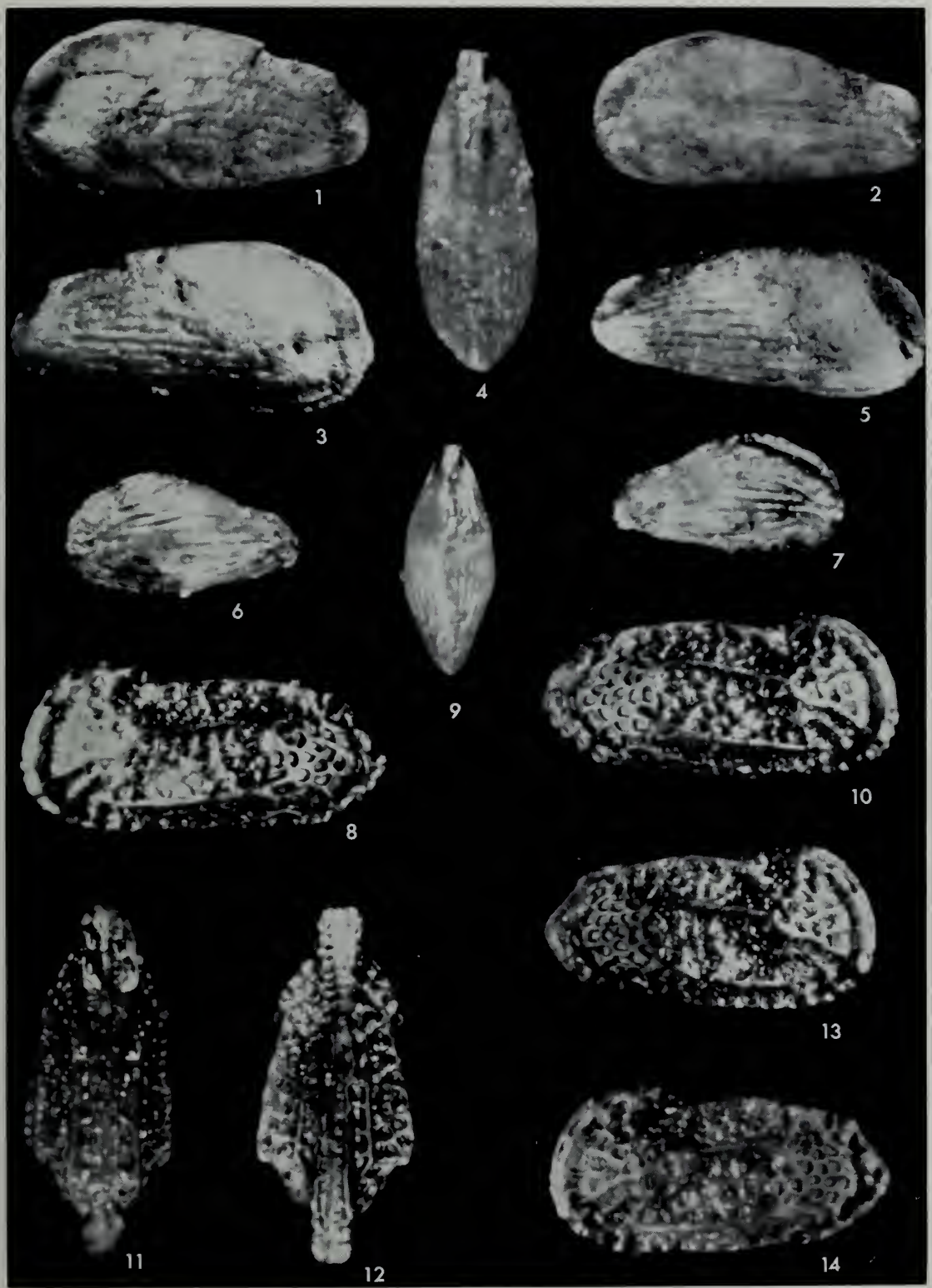
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PLATE 14

Costa (Paracosta) declivis subgen. et sp. nov.

FIG. 1. Dorsal view, carapace female, × 68. Paratype, Io. 4273. *Pellatispira* Beds, sample 3662, Rakhi Nala.

FIG. 2. Ventral view, carapace female, × 68. Paratype, Io. 3116. *Pellatispira* Beds, sample 3662, Rakhi Nala.

Costa (Paracosta) compitalis sp. nov.

FIGS. 3, 4, 7, 8. Dorsal, ventral, right and left views, carapace male, × 68. Paratype, Io. 4274. Upper Chocolate Clays (lower part), sample 3604, Rakhi Nala.

FIGS. 5, 6, 9, 10. Dorsal, ventral, right and left views, carapace female, × 68. Holotype, Io. 4323. Upper Chocolate Clays (lower part), sample 3604, Rakhi Nala.

Costa (Paracosta) disintegrata sp. nov.

FIG. 11. Left view, carapace male, × 68. Paratype, Io. 4275. Upper Chocolate Clays (lower part), sample 3622, Rakhi Nala.

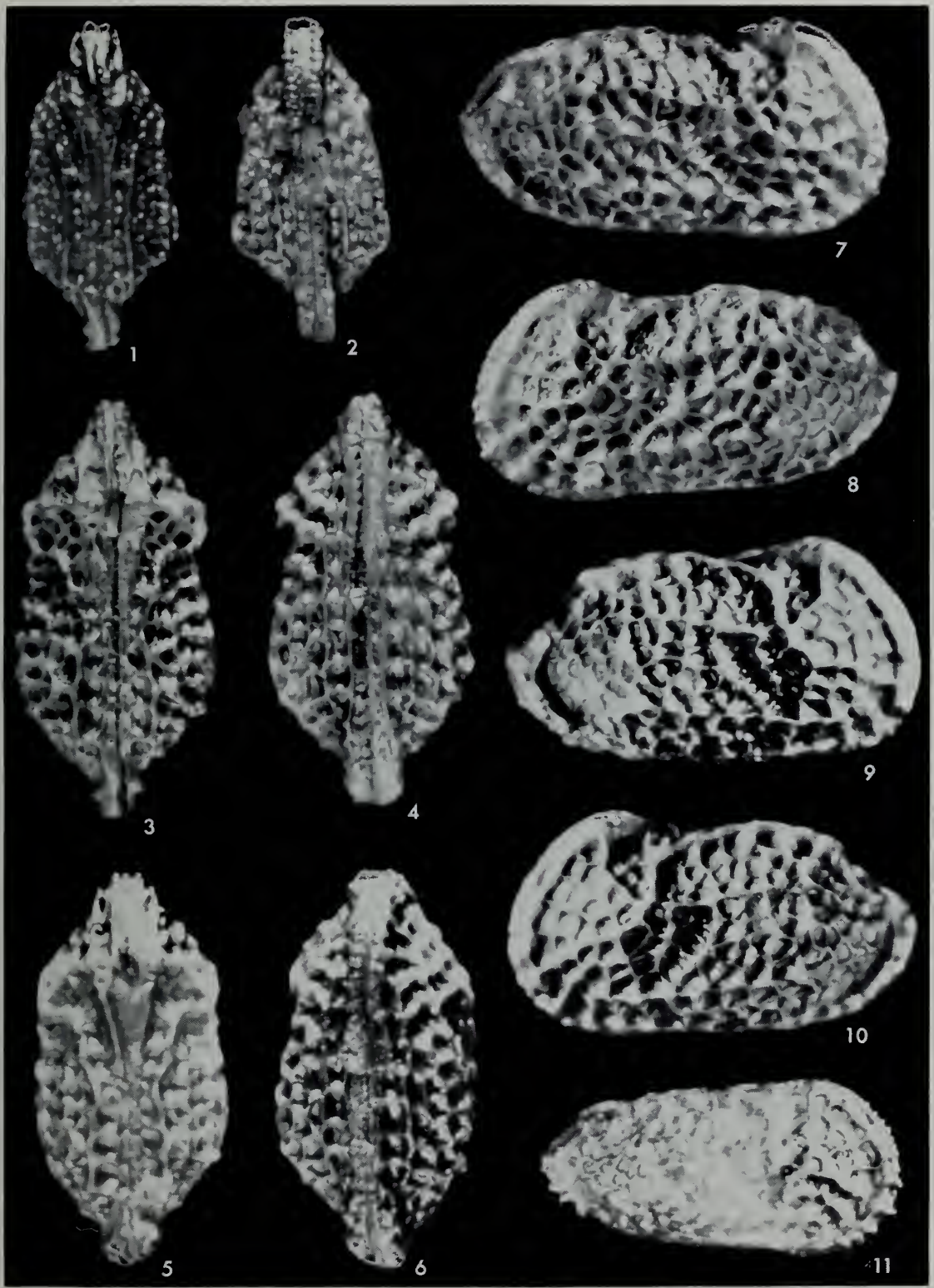
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PLATE 15

Costa (Paracosta) disintegrata sp. nov.

FIGS. 1, 2, 5, 6. Left, right, dorsal and ventral views, carapace female, × 68. Holotype, Io. 4324. Upper Chocolate Clays (lower part), sample 3621, Rakhi Nala.

FIGS. 3, 4. Dorsal and ventral views, carapace male, × 68. Paratype, Io. 4275. Upper Chocolate Clays (lower part), sample 3622, Rakhi Nala.

Echinocythereis (Echinocythereis) contexta sp. nov.

FIGS. 7, 10. Left and dorsal views, carapace male, × 68. Paratype, Io. 4276. Upper Palaeocene, sample 460-j, Sor Range, 8 miles east of Quetta.

FIGS. 8, 13. Left and dorsal views, carapace female, × 68. Holotype, Io. 4326. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

Echinocythereis (Echinocythereis) elongata sp. nov.

FIGS. 9, 11. Left and right views, carapace male, × 68. Paratype, Io. 3130. Rubbly Limestones, sample 3416, Rakhi Nala.

FIGS. 12, 14. Left and right views, carapace female, × 68. Holotype, Io. 4327. Rubbly Limestones, sample 3416, Rakhi Nala.

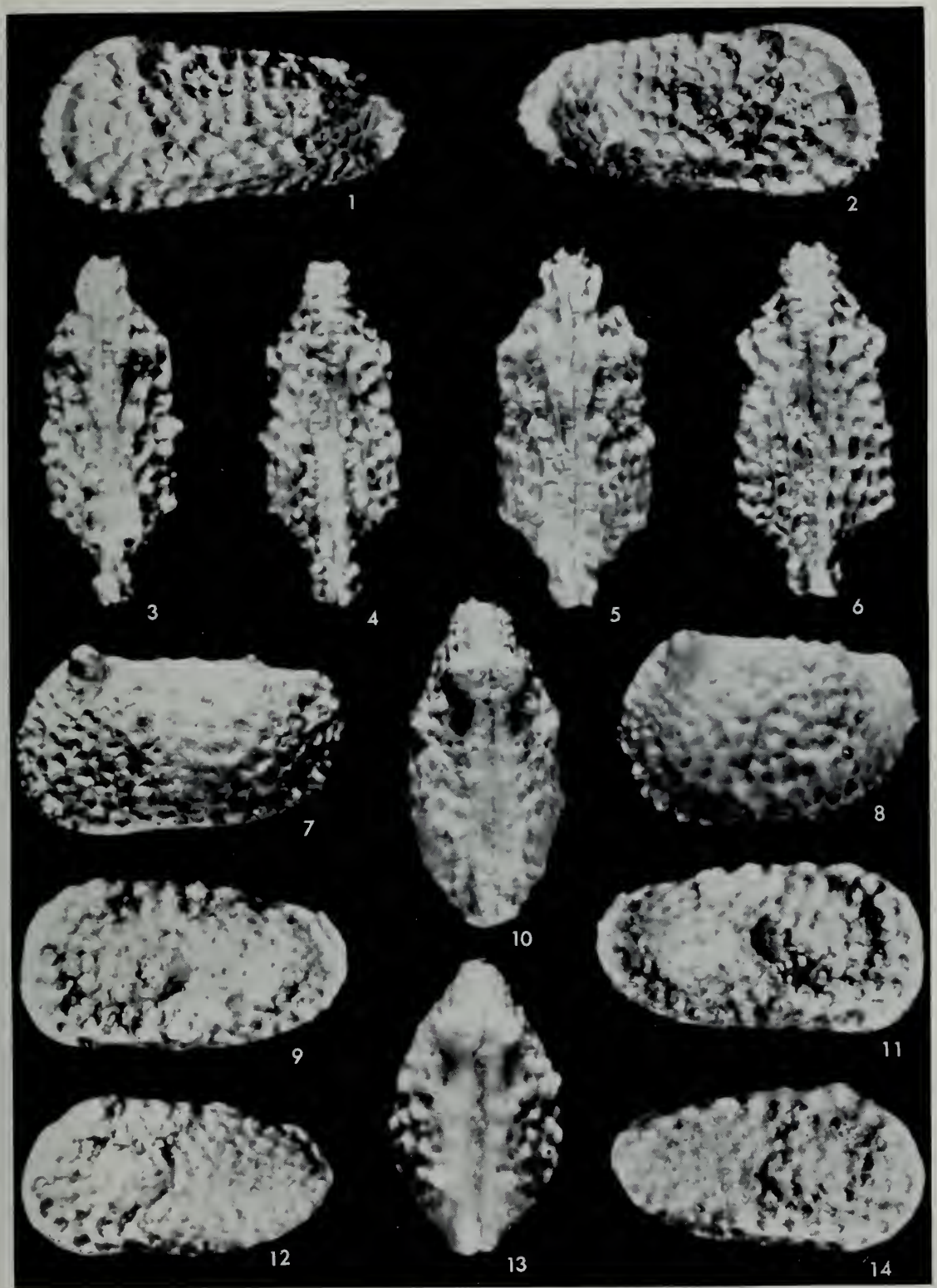
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PLATE 16

Echinocythereis (Echinocythereis) elongata sp. nov.

FIG. 1. Dorsal view, carapace female, × 68. Holotype, Io. 4327. Rubbly Limestones, sample 3416, Rakhi Nala.

FIG. 2. Dorsal view, carapace male, × 68. Paratype, Io. 3130. Rubbly Limestones, sample 3416, Rakhi Nala.

Echinocythereis (Scelidocythereis) multibullata subgen. et sp. nov.

FIGS. 3, 5, 6. Dorsal, left and right views, carapace male, × 68. Holotype, Io. 4328. Upper Chocolate Clays (upper part), sample 24161, Zao River.

FIGS. 4, 7, 8. Dorsal, right and left views, carapace female, × 68. Paratype, Io. 3134. Upper Chocolate Clays (upper part), sample 24161, Zao River.

FIG. 9. Internal view to show radial pore canals, right valve female, × 132. Paratype, Io. 4277. Upper Chocolate Clays (lower part), sample 24159, Zao River.

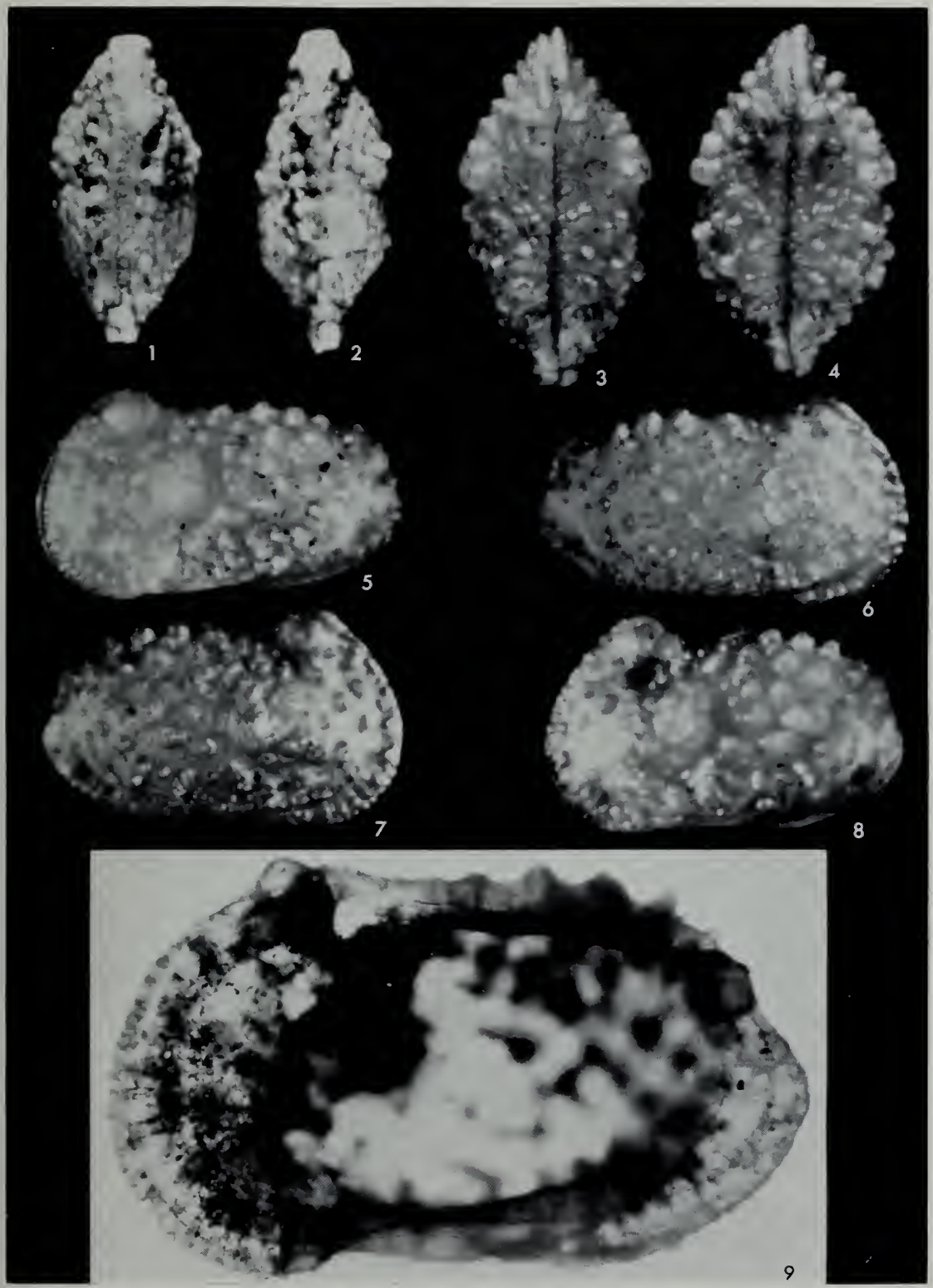
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PLATE 17

Echinocythereis (Scelidocythereis) multibullata sp. nov.

FIG. 1. Dorsal view of hinge, left valve female, × 146. Holotype, Io. 4327. Upper Chocolate Clays (lower part), sample 24159, Zao River.

FIG. 2. Dorsal view of hinge, right valve female, × 146. Paratype, Io. 4277. Upper Chocolate Clays (lower part), sample 24159, Zao River.

FIG. 7. Ventral view, carapace male, × 68. Paratype, Io. 3133. Upper Chocolate Clays (upper part), sample 24161, Zao River.

Echinocythereis (Scelidocythereis) sp.A

FIGS. 3, 4, 8, 9. Left, right, dorsal and ventral views, carapace, × 68. Io. 3129. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

Echinocythereis (Scelidocythereis) rasilis sp. nov.

FIGS. 5, 10. Left and ventral views, carapace male, × 68. Paratype, Io. 4278. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 6. Left view, carapace female, × 68. Holotype, Io. 4329. Lower Chocolate Clays, sample 3499, Rakhi Nala.

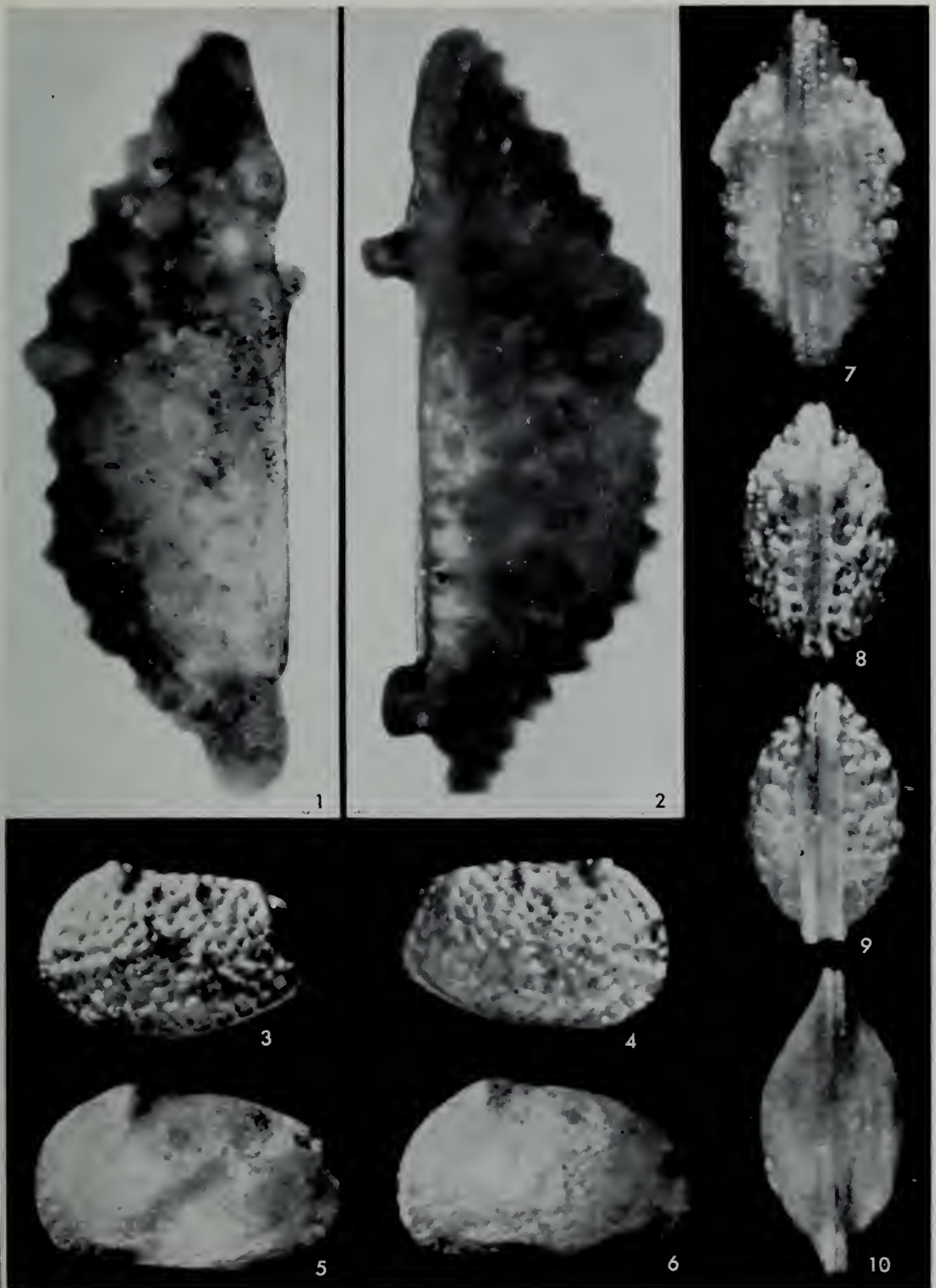
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PLATE 18

Echinocythereis (Scelidocythereis) rasilis sp. nov.

FIG. 1. Dorsal view, carapace male, × 68. Paratype, Io. 4278. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIGS. 2, 3. Dorsal and ventral views, carapace female, × 68. Holotype, Io. 4329. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 5. Right view, carapace male, × 68. Paratype, Io. 3131. Upper Chocolate Clays (lower part), sample 24157, Zao River.

FIG. 7. Right view, carapace female, × 68. Paratype, Io. 3132. Upper Chocolate Clays (lower part), sample 24145, Zao River.

Echinocythereis (Scelidocythereis) sparsa sp. nov.

FIGS. 4, 6. Dorsal and left views, carapace male, × 68. Paratype, Io. 4279. Upper Chocolate Clays (lower part), sample 24159, Zao River.

FIGS. 8, 9. Dorsal and left views, carapace female, × 68. Holotype, Io. 4330. Upper Chocolate Clays (lower part), sample 24159, Zao River.

Gyrocythere exaggerata gen. et sp. nov.

FIGS. 10, 12. External and internal views, left valve male, × 68. Paratype, Io. 3125. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIGS. 11, 14. External and internal views, right valve male, × 68. Paratype, Io. 3127. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIG. 13. Dorsal view, carapace male (specimen now split giving separate valves Io. 3125 + Io. 3127 above).

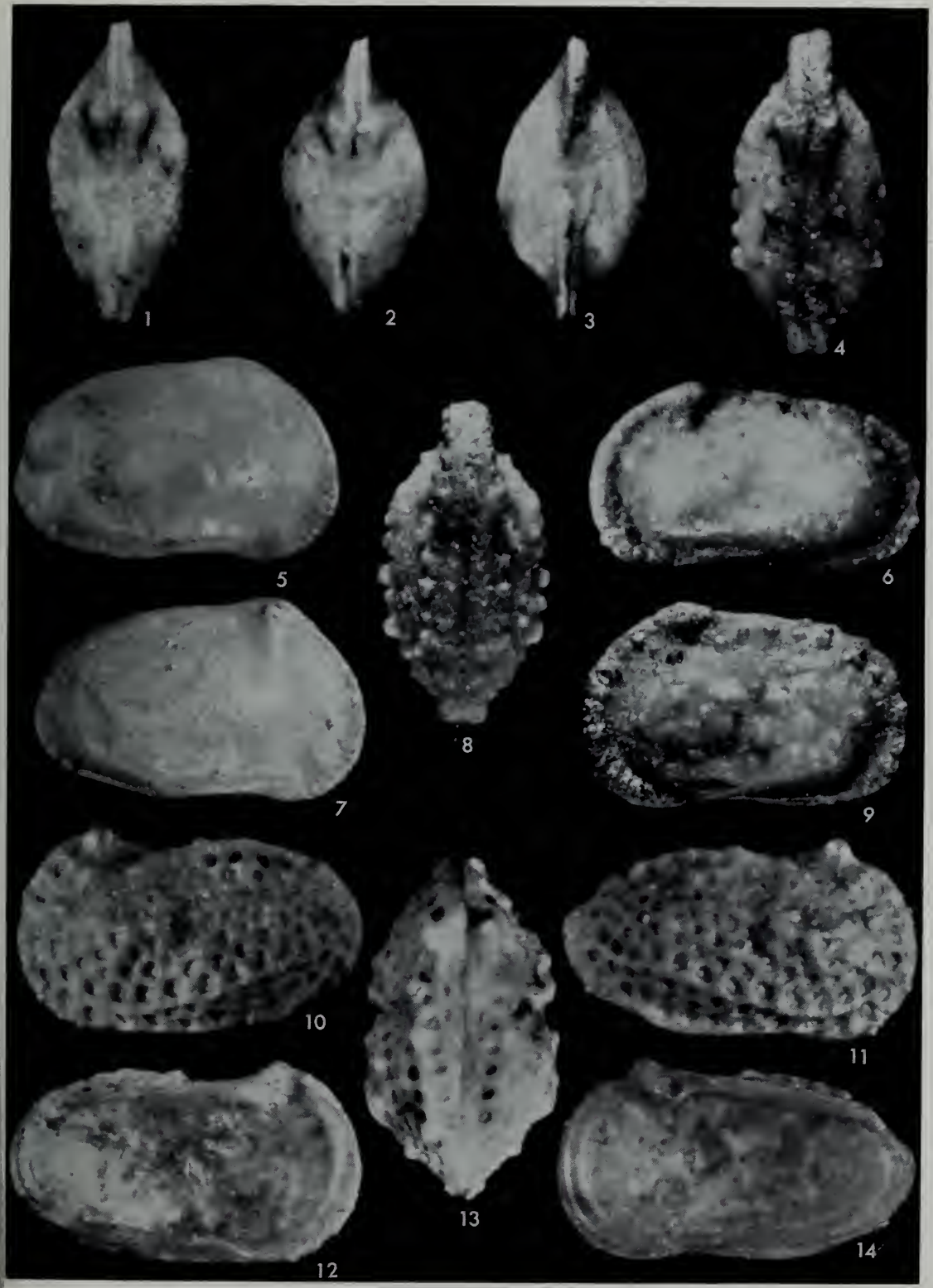
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PLATE 19

Gyrocythere exaggerata gen. et sp. nov.

FIGS. 1–4. Left, right, dorsal and ventral views, carapace female, × 68. Holotype, Io. 4331. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIG. 5. Muscle scars × 120 showing four adductors and a U-shaped frontal scar, right valve female. Paratype, Io. 4280. Upper Chocolate Clays (lower part), sample 24148, Zao River.

FIG. 6. Internal view to show radial pore canals, left valve male, × 134. Paratype, Io. 3126. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIG. 7. Internal view to show radial pore canals, right valve female, × 134. Paratype, Io. 3124. Upper Chocolate Clays (lower part), sample 24148, Zao River.

FIG. 8. Dorsal view of hinge × 145, left valve male. Paratype, Io. 3120. Upper Chocolate Clays (lower part), sample 24151, Zao River.

FIG. 9. Dorsal view of hinge × 145, right valve male. Paratype, Io. 3122. Upper Chocolate Clays (lower part), sample 24151, Zao River.

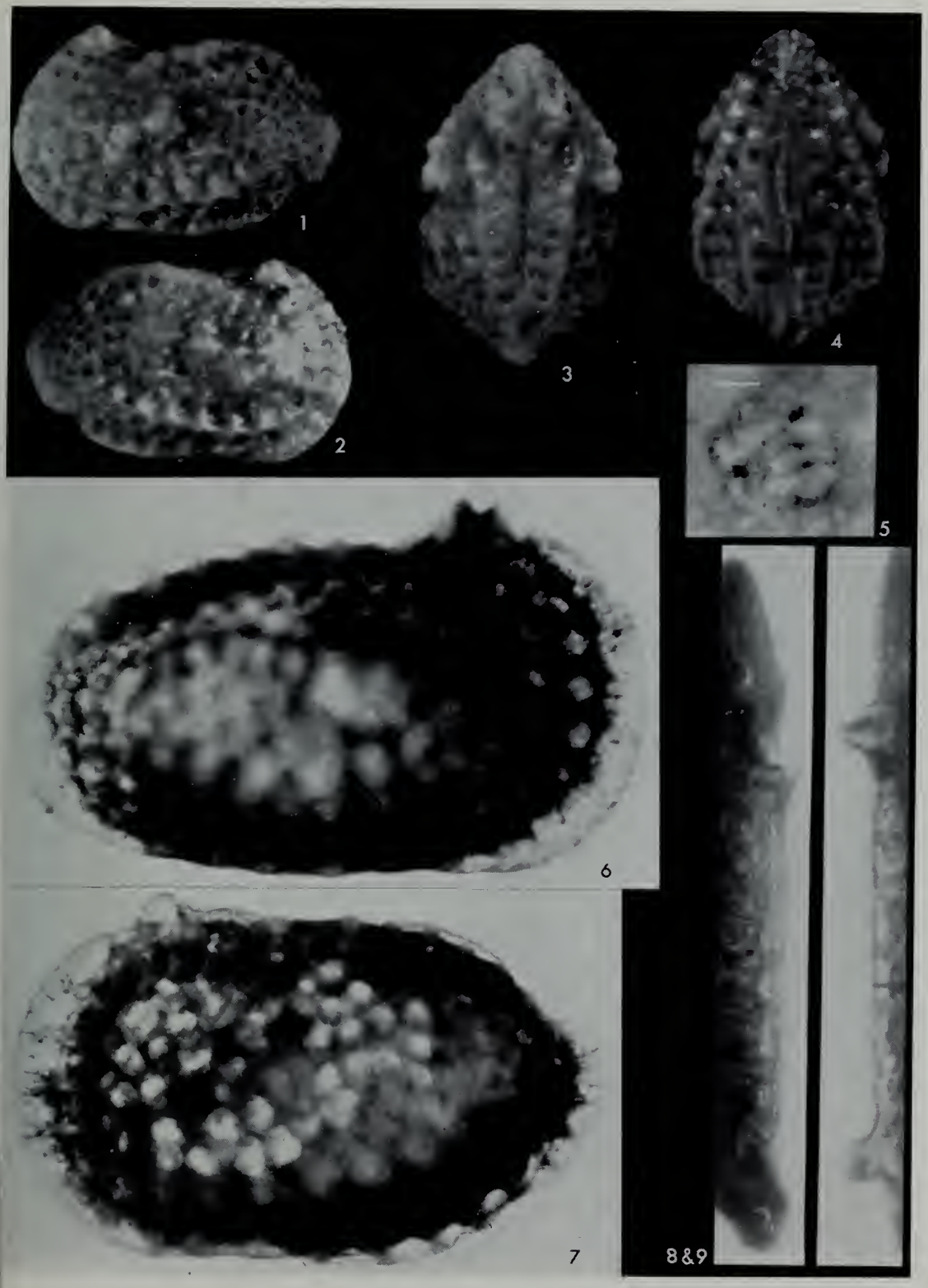
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PLATE 20

Gyrocythere exaggerata gen. et sp. nov.

FIG. 5. Dorsal view of hinge, right valve female, × 150. Paratype, Io. 3128. Upper Chocolate Clays (lower part), sample 24148, Zao River.

Gyrocythere parvicarinata sp. nov.

FIGS. 1, 2, 6, 7. Right, left, dorsal and ventral views, carapace male, × 68. Holotype, Io. 4334. Green and Nodular Shales, sample 3407, Rakhi Nala.

FIGS. 3, 4, 8, 12. Right, left, dorsal and ventral views, carapace female, × 68. Paratype, Io. 4281. Green and Nodular Shales, sample 3407, Rakhi Nala.

Gyrocythere grandilaevis sp. nov.

FIGS. 9, 10. Left and right views, carapace male, × 68. Holotype, Io. 4332. Shales with Alabaster, sample 3463, Rakhi Nala.

FIGS. 11, 12. Left and right views, carapace female, × 68. Paratype, Io. 4282. Shales with Alabaster, sample 3463, Rakhi Nala.

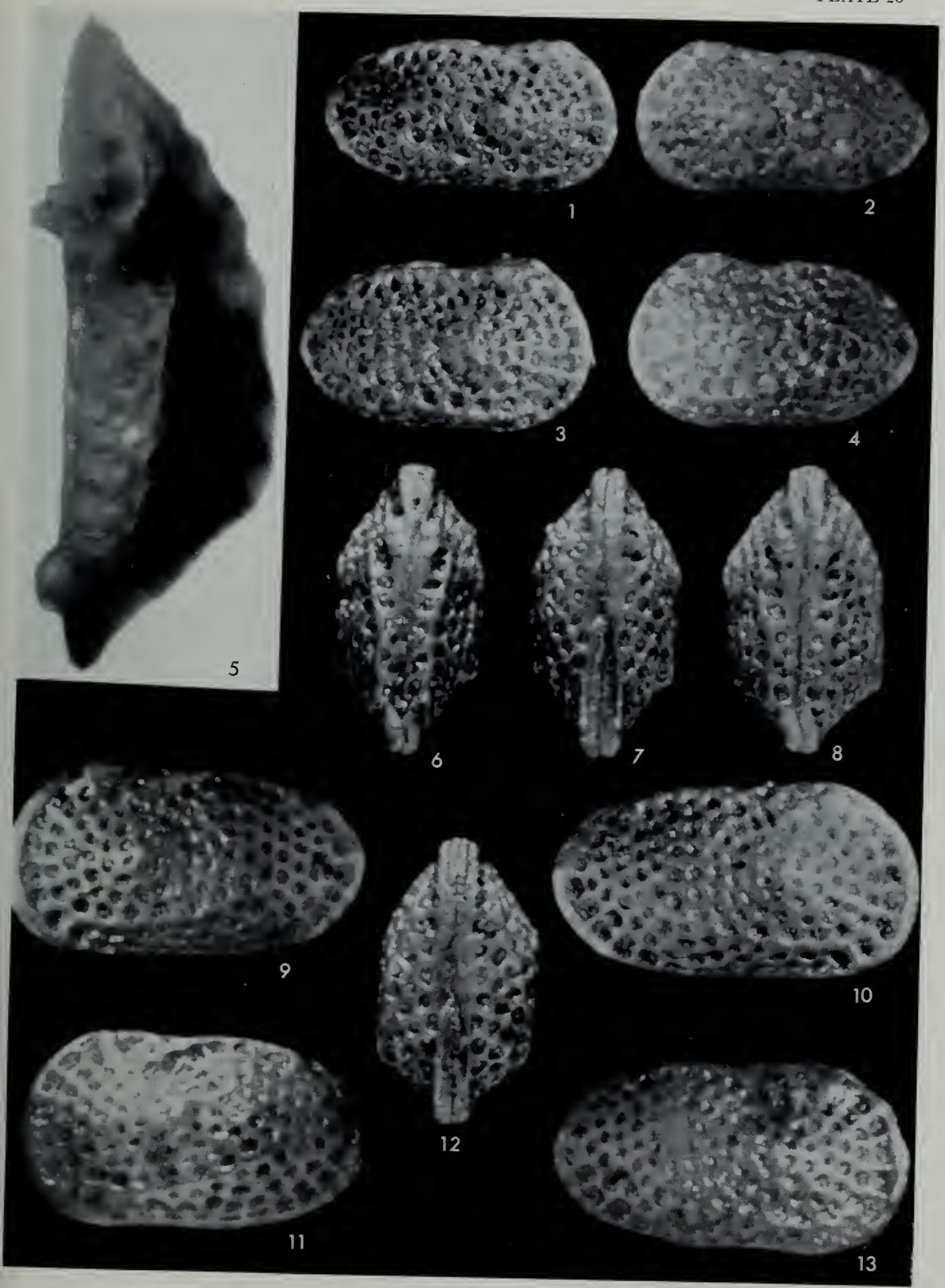
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PLATE 21

Gyrocythere grandilaevis sp. nov.

FIGS. 1, 2. Dorsal and ventral views, carapace male, × 68. Holotype, Io. 4332. Shales with Alabaster, sample 3463, Rakhi Nala.

FIGS. 3, 4. Dorsal and ventral views, carapace female, × 68. Paratype, Io. 4282. Shales with Alabaster, sample 3463, Rakhi Nala.

Gyrocythere mitigata sp. nov.

FIGS. 5–8. Left, right, dorsal and ventral views, carapace male, × 70. Holotype, Io. 4333. Lower Chocolate Clays, sample 24131, Zao River.

FIGS. 9, 11. Dorsal and external views, left valve female, × 70. Paratype, Io. 3119. Lower Chocolate Clays, sample 24131, Zao River.

FIG. 10. Right view, carapace female, × 70. Paratype, Io. 4283. Lower Chocolate Clays, sample 34131, Zao River.

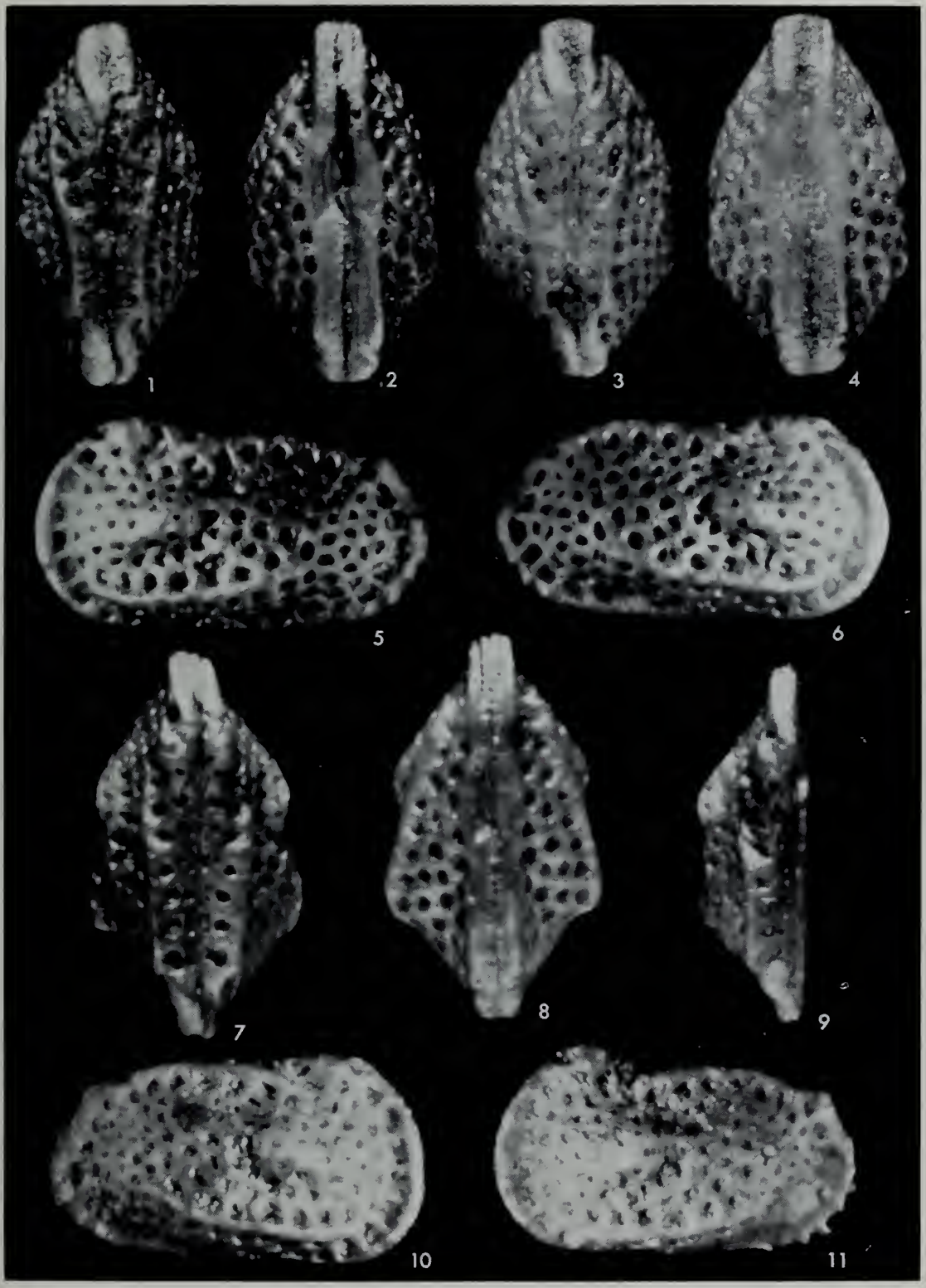
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PLATE 22

Gyrocythere perfecta sp. nov.

FIGS. 1, 2, 5, 9. Left, right, dorsal and ventral views, carapace male, × 68. Paratype, Io. 4281. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIGS. 3, 4, 7, 8. Left, right, dorsal and ventral views, carapace female, × 68. Holotype, Io. 4335. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 6. Muscle scars × 140, right valve male. Paratype, Io. 3121. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 10. Internal view to show radial pore canals, right valve female, × 134. Paratype, Io. 3120. Lower Chocolate Clays, sample 3498, Rakhi Nala.

Hermanites cracens sp. nov.

FIG. 11. Ventral view, carapace, × 70. Holotype, Io. 4336. Gorge Beds, sample 3111, Rakhi Nala.

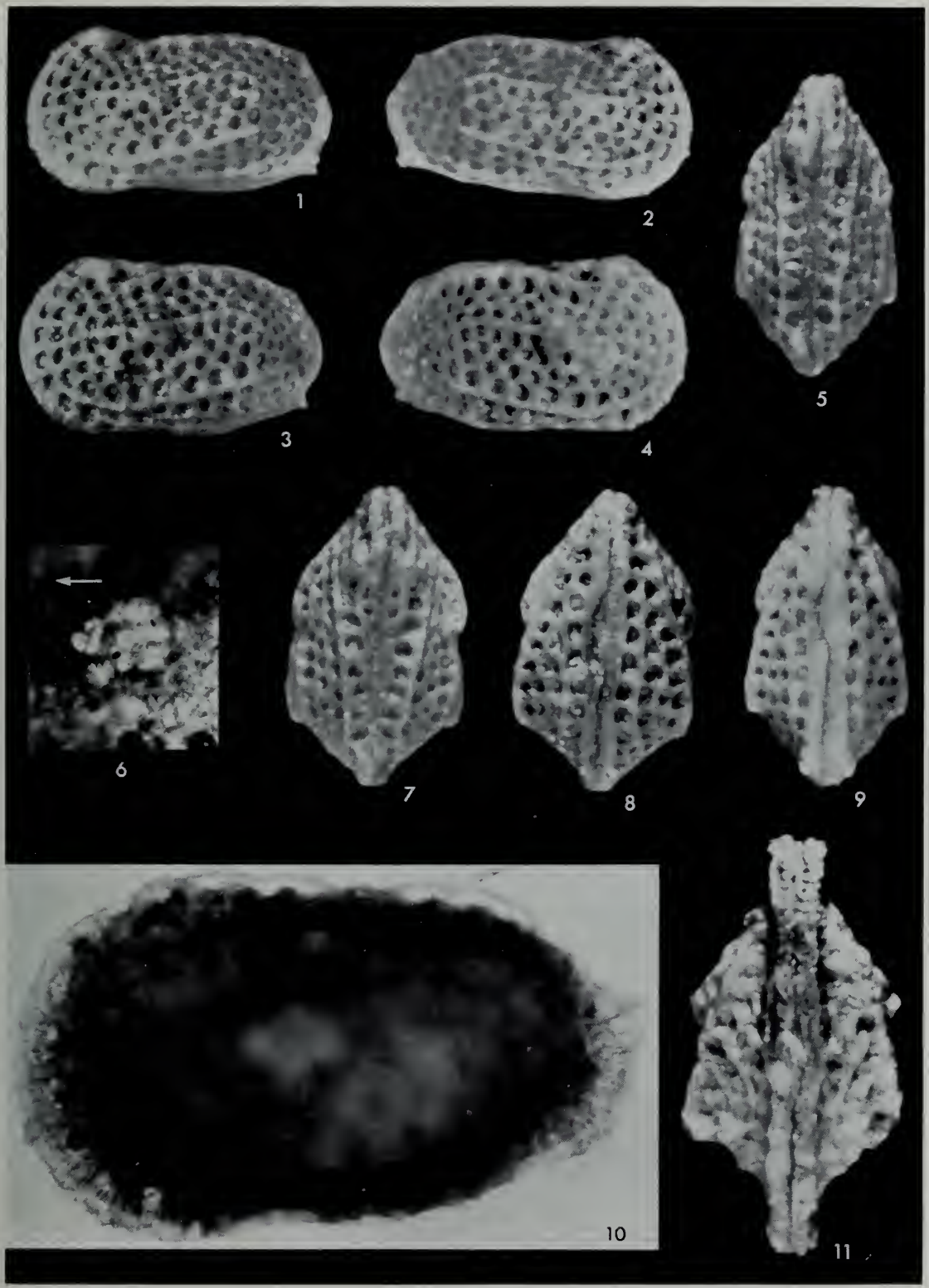
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PLATE 23

Hermanites cracens sp. nov.

FIGS. 1–3. Left, right and dorsal views, carapace, × 70. Holotype, Io. 4336. Gorge Beds, sample 3111, Rakhi Nala.

Hermanites scopus sp. nov.

FIGS. 4–7. Left, dorsal, ventral and right views, carapace male, × 70. Holotype, Io. 4338. Upper Chocolate Clays (lower part), sample 24148, Zao River.

FIGS. 8–10. Right, dorsal and ventral views, carapace female, × 70. Paratype, Io. 4285. Lower Chocolate Clays, sample 3499, Rakhi Nala.

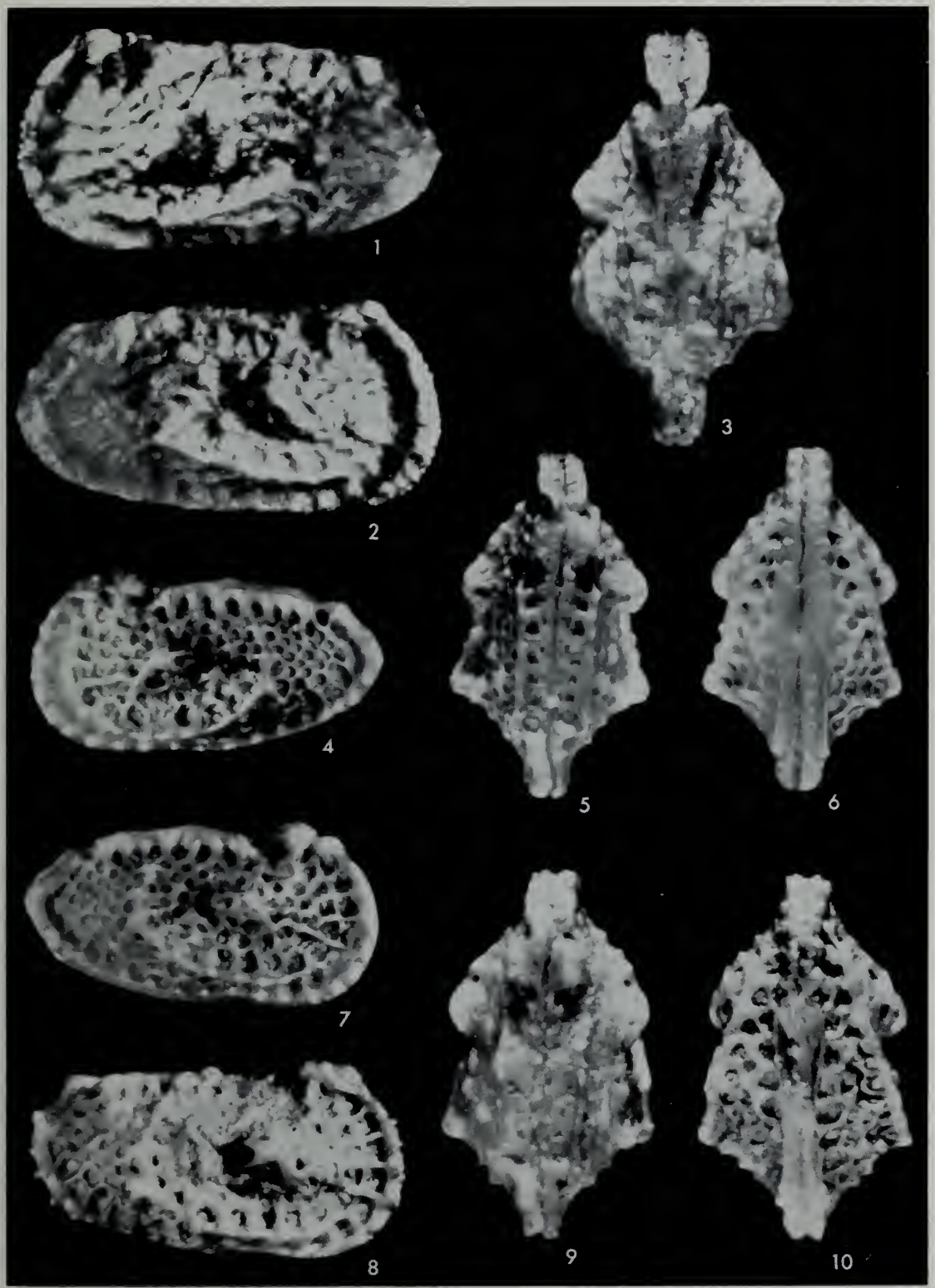
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PLATE 24

Hermanites palmatus sp. nov.

FIGS. 1, 2, 5. Dorsal, ventral and left views, carapace male, × 70. Paratype, Io. 4286. Upper Chocolate Clays (lower part), sample 24156, Zao River.

FIGS. 3, 4, 7. Dorsal, ventral and right views, carapace female, × 70. Paratype, Io. 3117. Upper Chocolate Clays (lower part), sample 24156, Zao River.

FIGS. 6, 8, 9, 11. Dorsal, external, internal and ventral views, left valve female, × 70. Holotype, Io. 4337. Upper Chocolate Clays (lower part), sample 24152, Zao River.

FIG. 12. External view, left valve female, × 70. Paratype, Io. 3118. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

Occultocythereis interrupta sp. nov.

FIGS. 10, 13, 15, 16. Left, right, dorsal and ventral views, carapace male, × 116. Paratype, Io. 4287. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 14, 17, 18. Right, dorsal and ventral views, carapace female, × 116. Holotype, Io. 4339. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

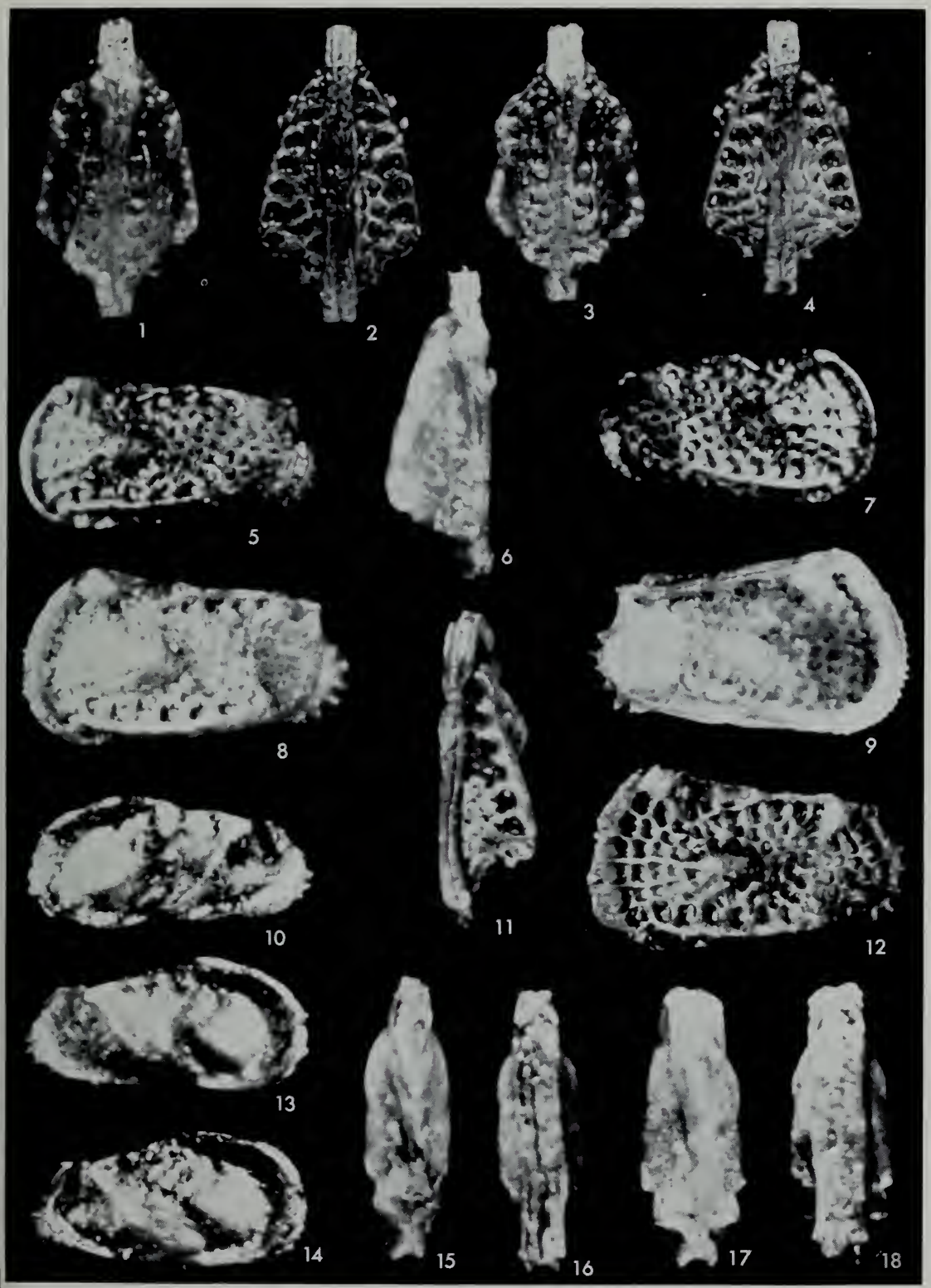
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PLATE 25

Occultocythereis sp.A

FIGS. 1, 2, 5. Left, right and ventral views, carapace, × 116. Io. 3136. Lower Rakhi Gaj Shales, sample 3672, Rakhi Nala.

Occultocythereis spilota sp. nov.

FIGS. 3, 4, 8, 9. Left, right, dorsal and ventral views, carapace male, × 120. Paratype, Io. 4288. Green and Nodular Shales, sample 3177, Rakhi Nala.

FIGS. 6, 7, 10, 11. Left, right, dorsal and ventral views, carapace female, × 120. Holotype, Io. 4342. Green and Nodular Shales, sample 3177, Rakhi Nala.

Occultocythereis peristicta sp. nov.

Morphotype A

FIGS. 13, 14, 17. Left, right and ventral views, carapace male, × 118. Paratype, Io. 4292. Upper Rakhi Gaj Shales, sample 3167, Rakhi Nala.

FIGS. 15, 16. Left and right views, carapace female, × 118. Holotype, Io. 4341. Upper Rakhi Gaj Shales, sample 3167, Rakhi Nala.

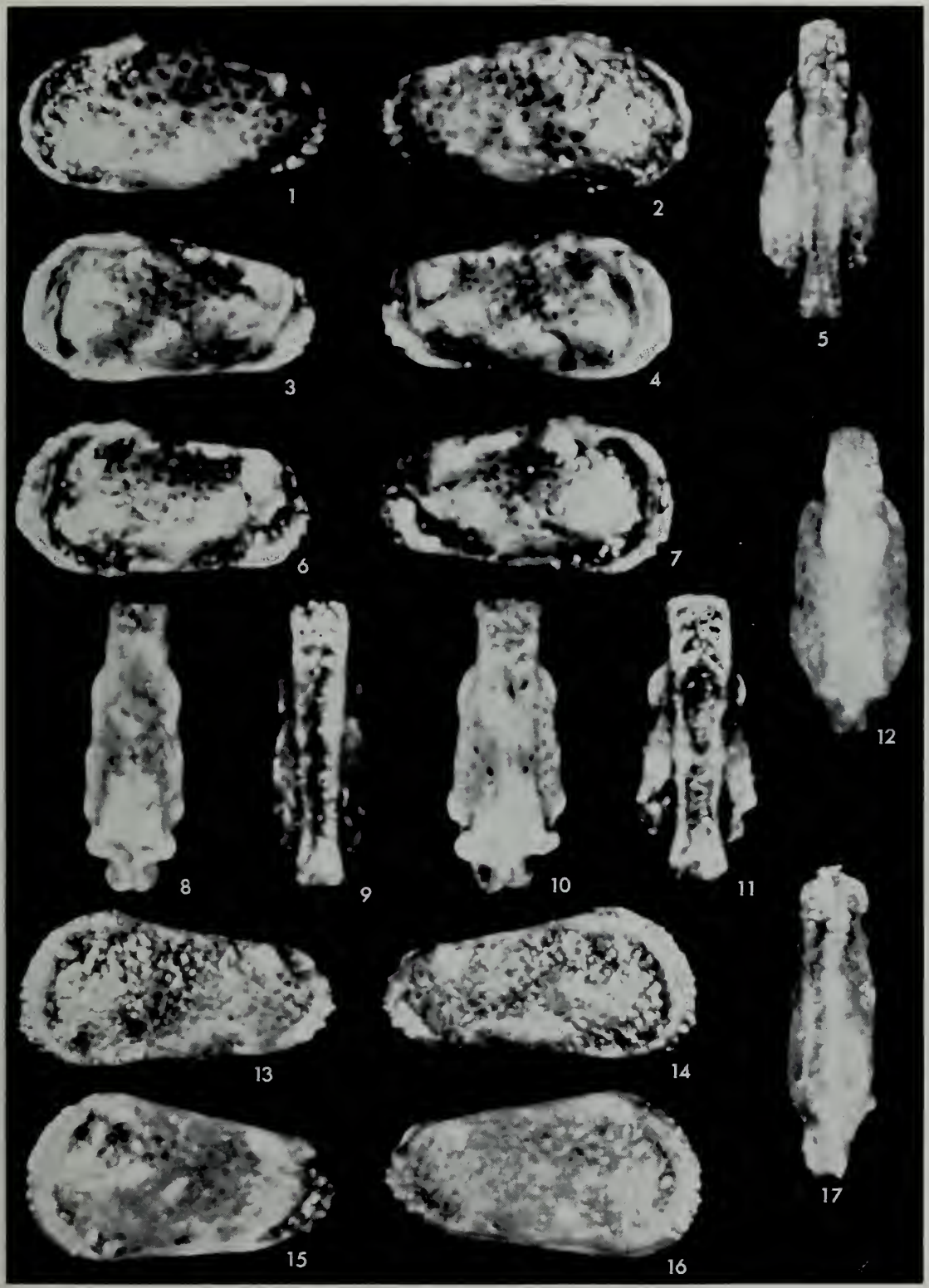
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PLATE 26

Occultocythereis peristicta sp. nov.

Morphotype A

FIG. 1. Dorsal view, carapace male, × 118. Paratype, Io. 4292. Upper Rakhi Gaj Shales, sample 3167, Rakhi Nala.

FIGS. 2, 3. Dorsal and ventral views, carapace female, × 118. Holotype, Io. 4341. Upper Rakhi Gaj Shales, sample 3167, Rakhi Nala.

Morphotype B

FIGS. 4, 6, 7. Ventral, left and right views, carapace male, × 118. Paratype, Io. 4293. Green and Nodular Shales, sample 3193, Rakhi Nala.

FIGS. 5, 8, 9. Ventral, left and right views, carapace female, × 118. Paratype, Io. 4291. Green and Nodular Shales, sample 3193, Rakhi Nala.

Morphotype C

FIGS. 10–12. Ventral, left and right views, carapace male, × 118. Paratype, Io. 4289. Green and Nodular Shales, sample 3191, Rakhi Nala.

FIGS. 13–15. Left, right and ventral views, carapace female, × 118. Paratype, Io. 4290. Green and Nodular Shales, sample 3191, Rakhi Nala.

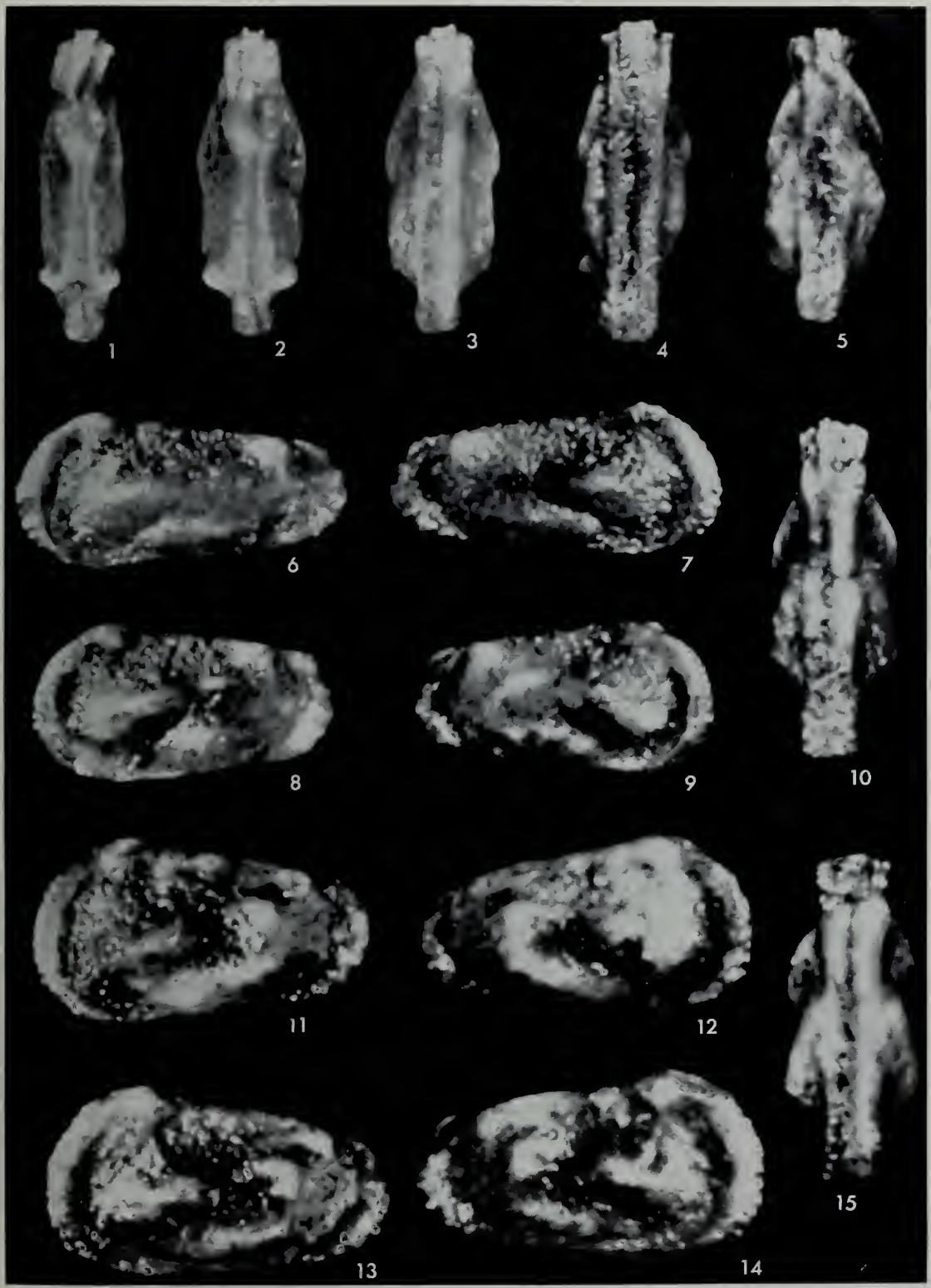
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PLATE 27

Occultocythereis peristicta sp. nov.

Morphotype D

FIGS. 1, 2, 5. Left, right and ventral views, carapace male, × 118. Paratype, Io. 3146. Green and Nodular Shales, sample 3191, Rakhi Nala.

FIGS. 3, 4, 6. Left, right and ventral views, carapace female, × 118. Paratype, Io. 3139. Green and Nodular Shales, sample 3191, Rakhi Nala.

Morphotype E

FIGS. 7, 9, 10. Ventral, right and left views, carapace male, × 118. Paratype, Io. 3137. Rubbly Limestones, sample 3418, Rakhi Nala.

FIGS. 8, 11, 12. Ventral, left and right views, carapace female, × 118. Paratype, Io. 3138. Rubbly Limestones, sample 3418, Rakhi Nala.

Occultocythereis indistincta sp. nov.

FIGS. 13, 14. Ventral and right views, carapace male, × 120. Paratype, Io. 3135. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 15. Right view, carapace female, × 120. Holotype, Io. 4340. Lower Chocolate Clays, sample 3499, Rakhi Nala.

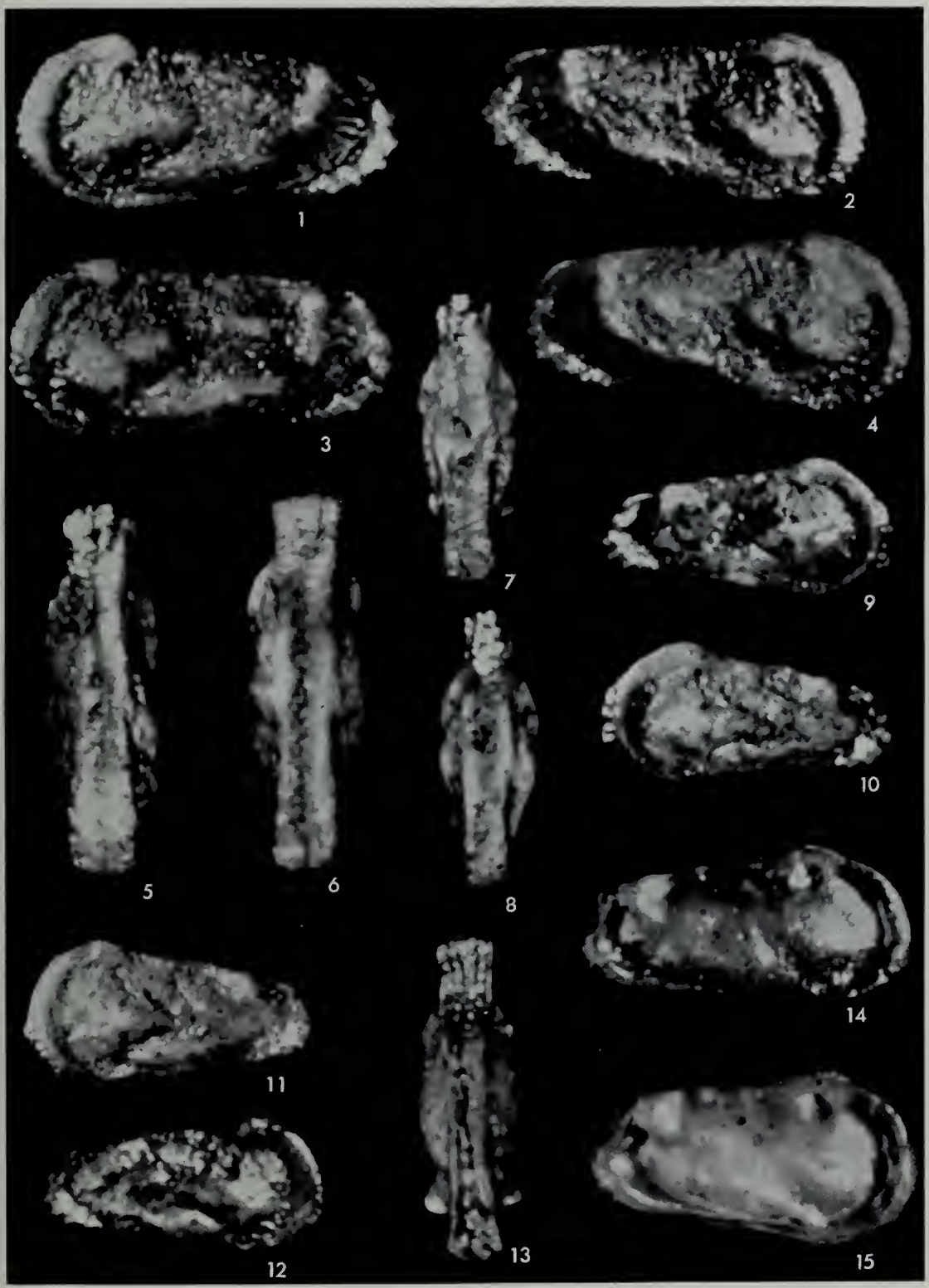
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PLATE 28

Occultocythereis indistincta sp. nov.

FIGS. 1, 3, 4. Left, dorsal and ventral views, carapace female, × 120. Holotype, Io. 4340. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 2. Dorsal view, carapace male, × 120. Paratype, Io. 3135. Lower Chocolate Clays, sample 3499, Rakhi Nala.

Patagonacythere? nidulus sp. nov.

FIGS. 5–8. Left, right, dorsal and ventral views, carapace male, × 70. Paratype, Io. 3096. Upper Chocolate Clays (upper part), sample 24173, Zao River.

FIGS. 9–12. Left, right, dorsal and ventral views, carapace female, × 70. Holotype, Io. 4349 Upper Chocolate Clays (lower part), sample 24173, Zao River.

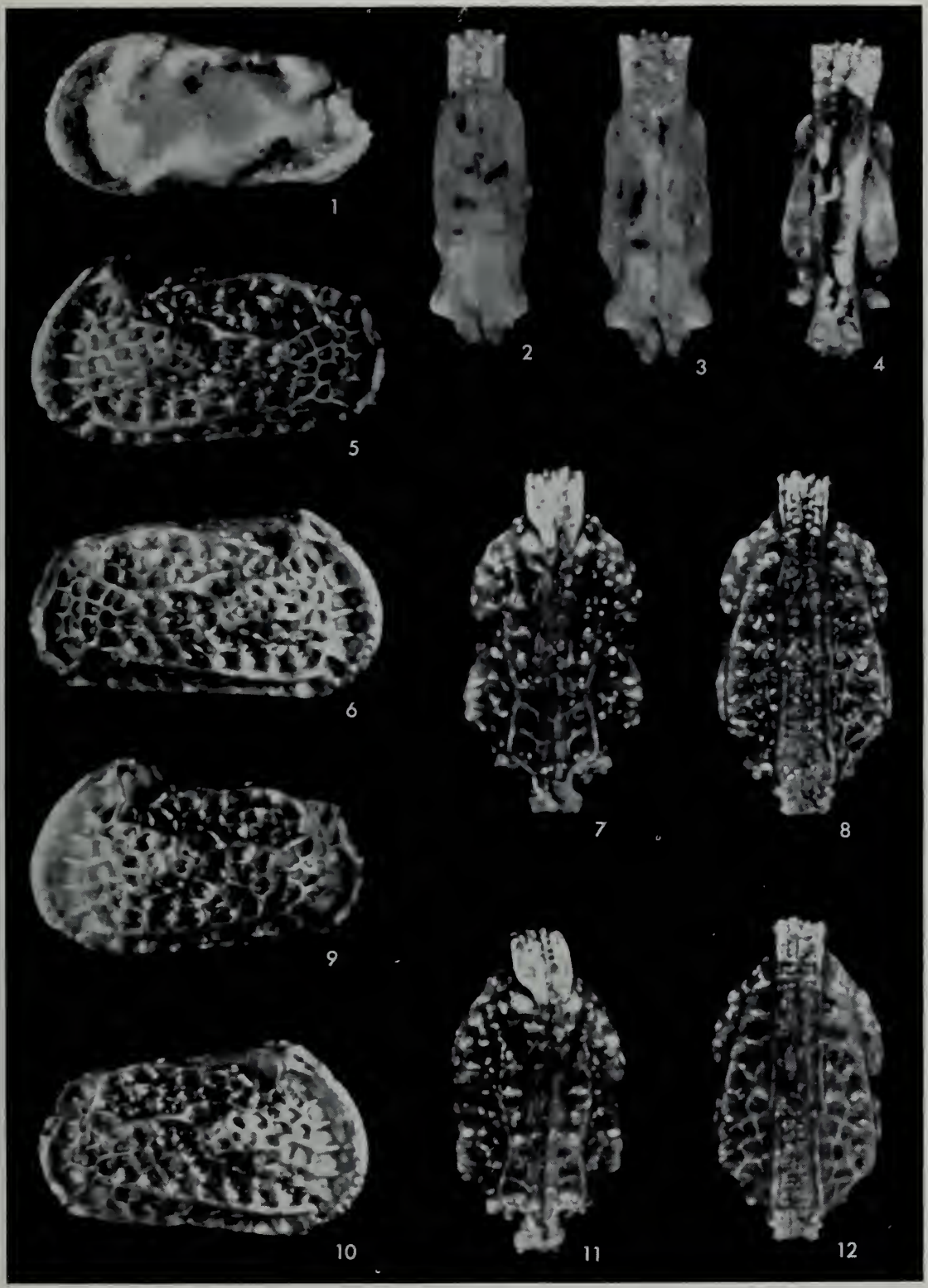
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PLATE 29

Patagonacythere? nidulus sp. nov.

Specimens showing exaggerated normal pores after being cleaned in the ultrasonic vibrator.

FIGS. 1, 2. 1, Internal view to show radial pore canals, × 160 ; 2, Dorsal view of hinge, × 150. Left valve female. Paratypes, Io. 3097. Upper Chocolate Clays (upper part), sample 24170, Zao River.

FIG. 3. Dorsal view of hinge, right valve female, × 150. Paratype, Io. 3098. Upper Chocolate Clays (upper part), sample 24170, Zao River.

FIG. 4. Muscle scars × 260. Right valve male. Paratype, Io. 4295. Upper Chocolate Clays (upper part), sample 34170, Zao River.

Phalcocythere horrescens (Bosquet) gen. nov.

FIG. 5. Anterior radial pore canals, × 212. Left valve. Io. 4257. Lutetian IV (sample CAB 1002, Keij 1957, p. 19), Grignon, Paris Basin.

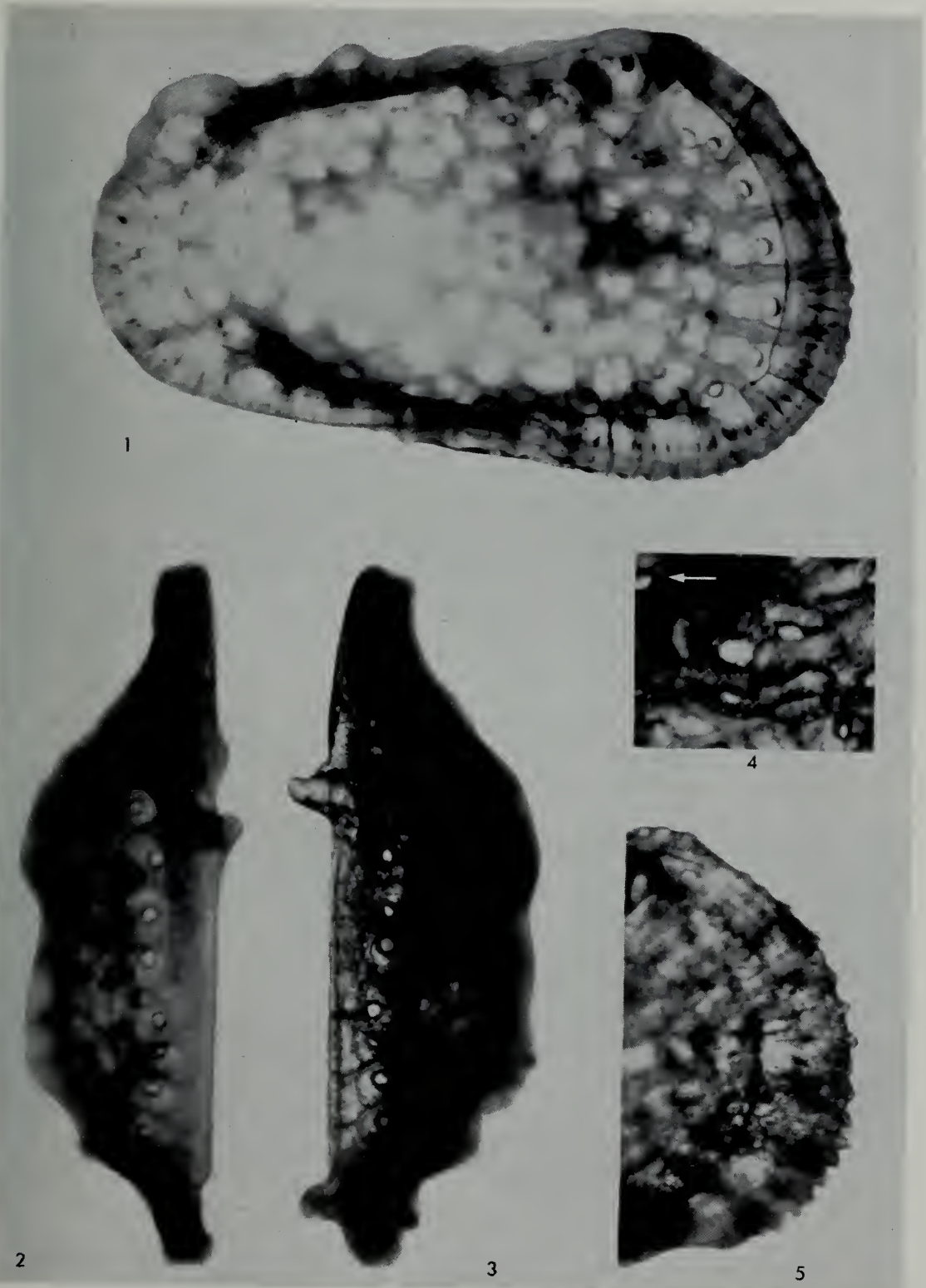
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PLATE 30

Phalcocythere horrescens (Bosquet) gen. nov.

FIGS. 1, 2. External and internal views, left valve, × 68. Io. 4254. Lutetian IV (sample CAB 1002, Keij 1957, p. 19), Grignon, Paris Basin.

FIGS. 3, 4. Dorsal and external views, left valve, × 68. Io. 4253. Lutetian IV (sample CAB 1002, Keij 1957, p. 19), Grignon, Paris Basin.

FIG. 5. Muscle scars × 195. Right valve. Io. 4255. Lutetian IV (sample CAB 1002, Keij 1957, p. 19), Grignon, Paris Basin.

FIG. 6. Internal view, right valve, × 132. Io. 4256. Lutetian, Villiers-St.-Frederic, Paris Basin.

Phalcocythere improcera sp. nov.

(See Pl. 33, figs. 12, 13 for hinge).

FIG. 7. Anterior radial pore canals × 224. Left valve female. Paratype, Io. 4295. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 8, 9. Left and right views, carapace male, × 68. Holotype, Io. 4344. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 10, 11. Left and right views, carapace female, × 68. Paratype, Io. 4258. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIG. 12. Anterior radial pore canals × 224. Right valve female. Paratype, Io. 4296. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

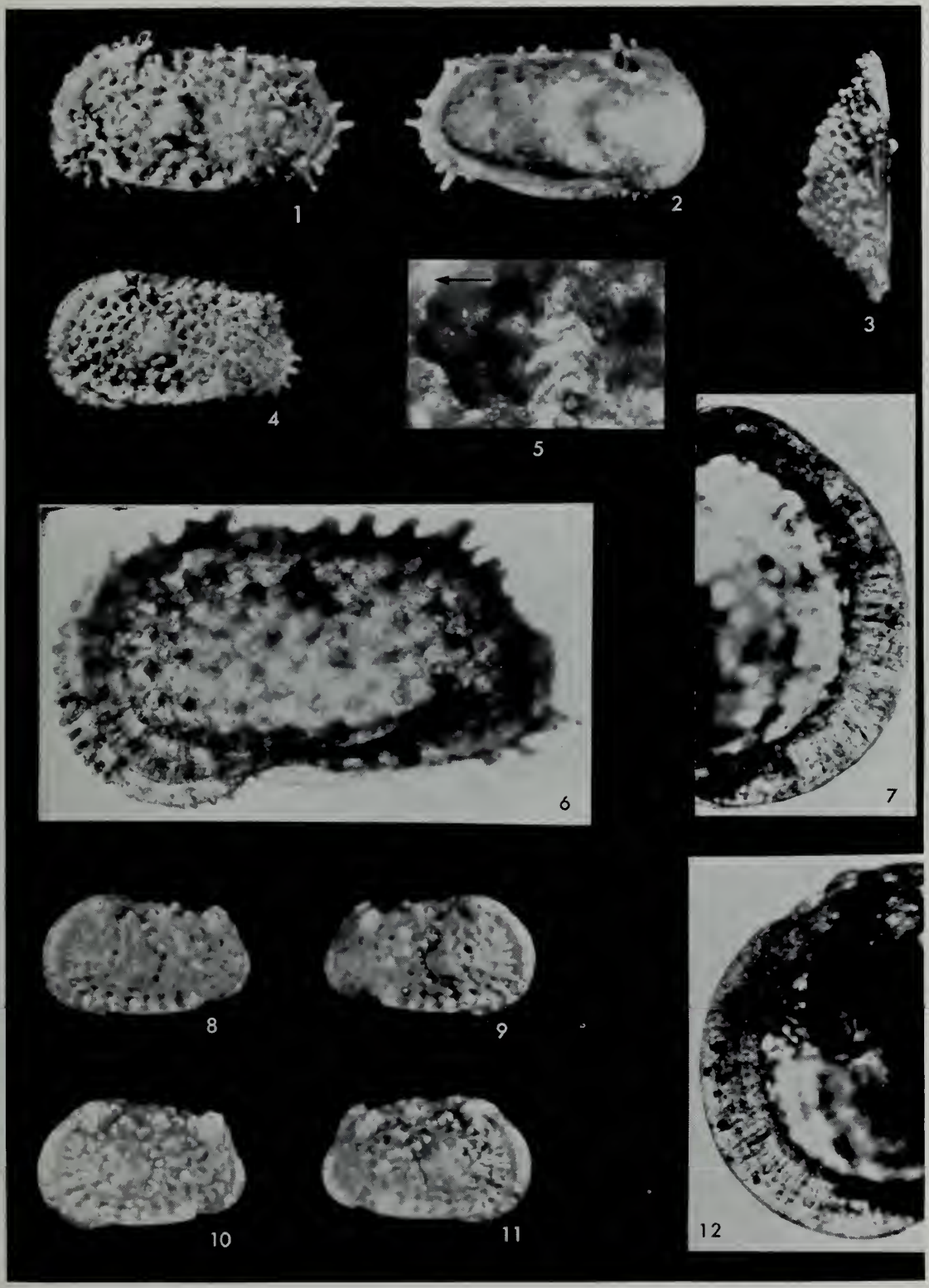
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PLATE 31

Phalcocythere improcera sp. nov.

FIGS. 1, 2. Dorsal and ventral views, carapace male, × 68. Holotype, Io. 4344. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 3, 4. Dorsal and ventral views, carapace female, × 68. Paratype, Io. 4258. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

Phalcocythere rete sp. nov.

FIGS. 5–8. Left, right, dorsal and ventral views, carapace male, × 68. Paratype, Io. 3099. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 9–10. Dorsal and left views, carapace female, × 68. Paratype, Io. 4297. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIG. 11. External view, right valve female, × 68. Holotype, Io. 4348. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIG. 12. External view of valve female, × 68. Paratype, Io. 3141. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

Phalcocythere retispinata sp. nov.

FIGS. 13, 14, 17. Left, right and dorsal views, carapace male, × 68. Paratype, Io. 3165. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 15, 16. Left and right views, carapace female, × 68. Holotype, Io. 4345. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

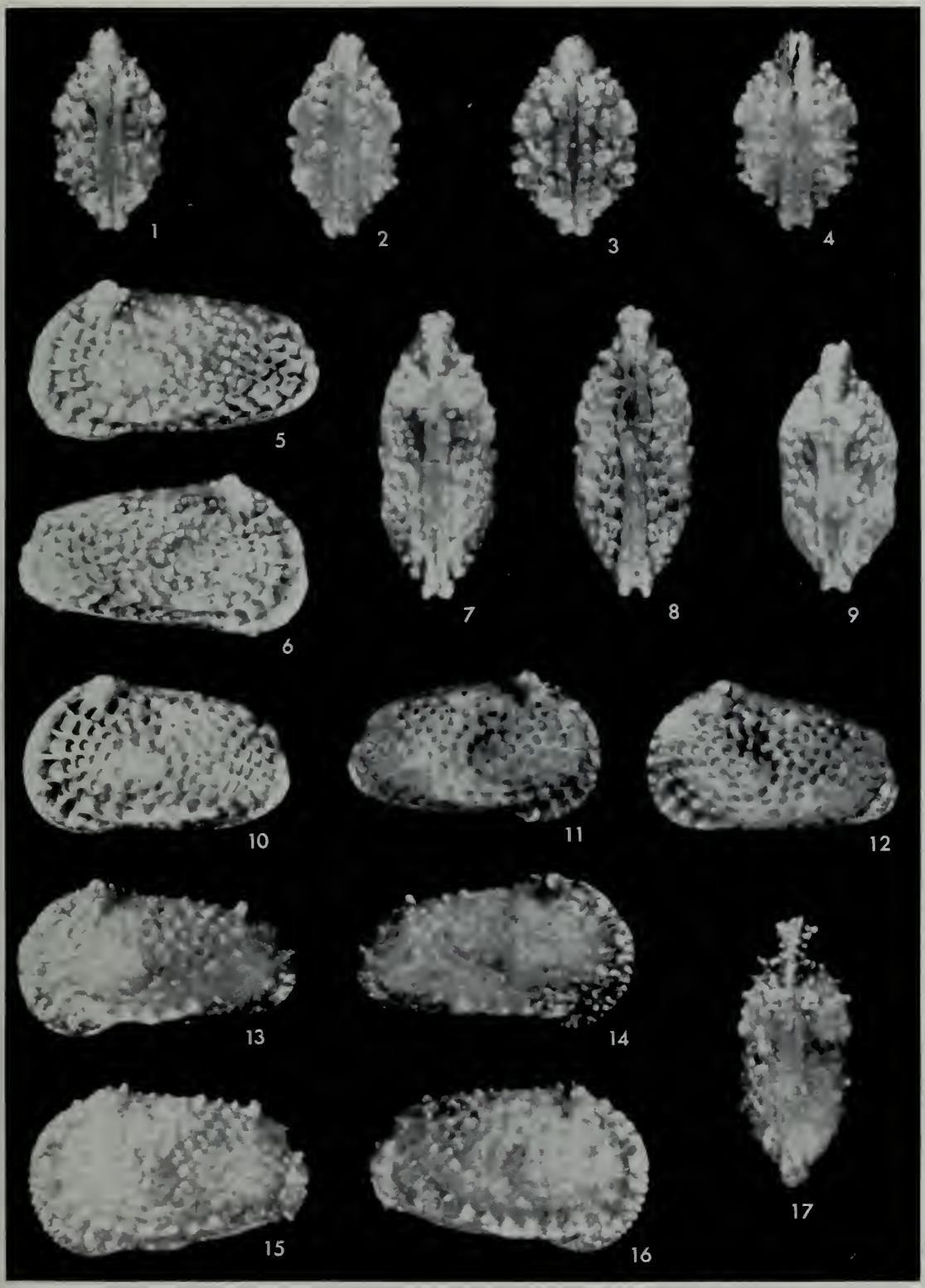
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PLATE 32

Phalcocythere retispinata sp. nov.

FIG. 1. Ventral view, carapace male, × 68. Paratype, Io. 3165. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 2, 3. Ventral and dorsal views, carapace female, × 68. Holotype, Io. 4345. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

Phalcocythere sentosa sp. nov.

FIGS. 4, 5, 8, 10. Dorsal, left, right and ventral views, carapace male, × 68. Holotype, Io. 4346. Upper Rakhi Gaj Shales, sample 3167, Rakhi Nala.

FIGS. 6, 7, 9. Left, dorsal and right views, carapace female, × 68. Paratype, Io. 4298. Upper Rakhi Gaj Shales, sample 3167, Rakhi Nala.

Phalcocythere dissenta sp. nov.

FIGS. 11, 13, 14, 18. Left, right, dorsal and ventral views, carapace male, × 68. Holotype, Io. 4343. Shales with Alabaster, sample 3456, Rakhi Nala.

FIGS. 12, 15–17. Left, right, dorsal and ventral views, carapace female, × 68. Paratype, Io. 4299. Shales with Alabaster, sample 3456, Rakhi Nala.

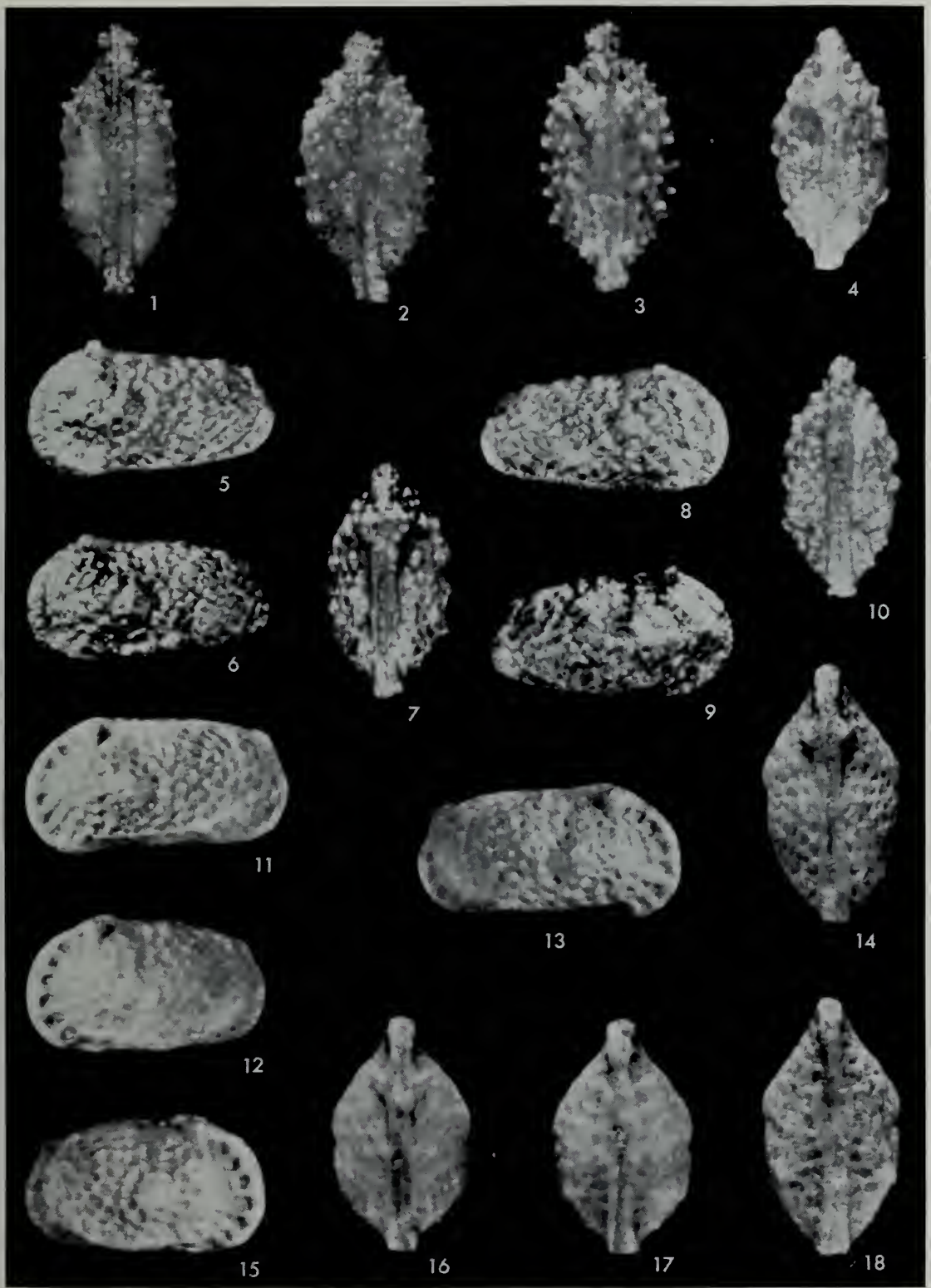
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PLATE 33

Phalcocythere spinosa sp. nov.

FIGS. 1, 2, 7, 8. Left, right, dorsal and ventral views, carapace, × 68. Holotype, Io. 4347. Upper Chocolate Clays (upper part), sample 24161, Zao River.

Phalcocythere sp., cf. ***P. spinosa***

FIGS. 3, 4, 9. Left, right and ventral views, carapace male, × 68. Io. 4230. Upper Eocene, Lindi survey, 10–50 ft. above shore at Kitunga, Tanzania.

FIGS. 5, 6, 10. Left, right and dorsal views, carapace female, × 68. Io. 4231. Upper Eocene, Lindi survey, 10–50 ft. above shore at Kitunga, Tanzania.

FIG. 11. Muscle scars × 210, fragment of right valve female. Io. 4232. Upper Eocene, Lindi survey, 10–50 ft. above shore at Kitunga, Tanzania.

Phalcocythere horrescens (Bosquet) gen. nov.

FIG. 12. Dorsal view of hinge × 183, left valve. Io. 4257. Lutetian IV (sample CAB 1002, Keij 1957, p. 19), Grignon, Paris Basin.

FIG. 13. Dorsal view of hinge × 183, right valve. Io. 4255. Lutetian IV (sample CAB 1002, Keij 1957, p. 19), Grignon, Paris Basin.

Quadracythere (Hornibrookella) platybomus sp. nov.

FIGS. 14, 18. Right and dorsal view, carapace male, × 70. Holotype, Io. 4351. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIGS. 15, 19. Right and dorsal views, carapace female, × 70. Paratype, Io. 4300. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

Quadracythere (Hornibrookella) directa sp. nov.

FIG. 16. Left view, carapace male, × 70. Io. 4301. Green and Nodular Shales, sample 3403, Rakhi Nala.

FIG. 17. Left view, carapace female, × 70. Holotype, Io. 4350. Green and Nodular Shales, sample 3403, Rakhi Nala.

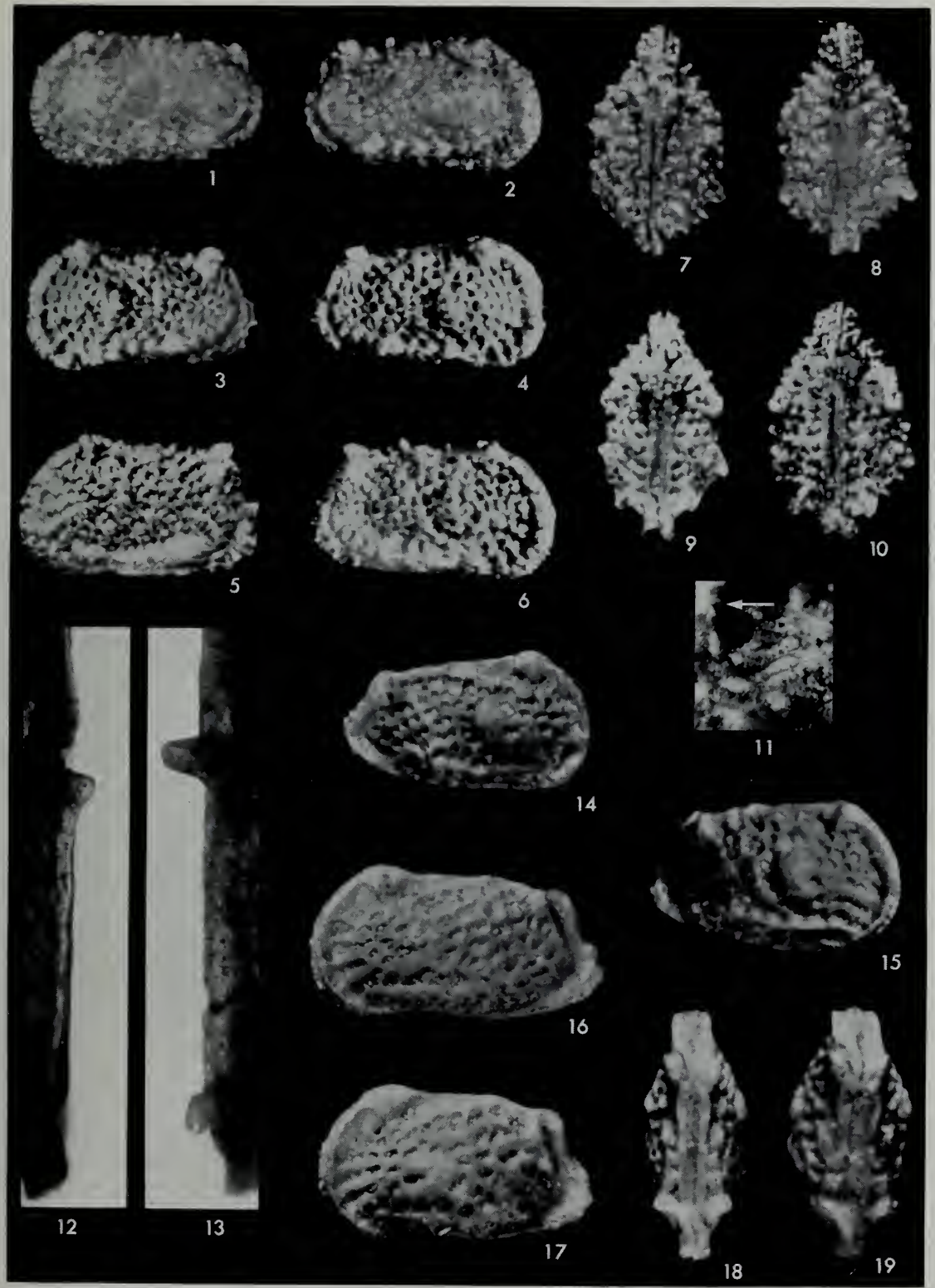
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PLATE 34

Quadracythere (Hornibrookella) directa sp. nov.

FIG. 1. Dorsal view, carapace male, × 70. Paratype, Io. 4301. Green and Nodular Shales, sample 3403, Rakhi Nala.

FIG. 2. Dorsal view, carapace female, × 70. Holotype, Io. 4350. Green and Nodular Shales, sample 3403, Rakhi Nala.

Quadracythere (Hornibrookella) arcana (Lubimova and Guha)

FIGS. 3–5. Right, left and dorsal views, carapace, × 70. Io. 3142. Lower Chocolate Clays, sample 3499, Rakhi Nala.

Quadracythere (Hornibrookella) subquadra sp. nov.

FIGS. 6, 8, 9. Left, dorsal and ventral views, carapace male, × 70. Paratype, Io. 4302. Upper Chocolate Clays (upper part), sample 24161, Zao River.

FIGS. 7, 10, 11. Left, right and dorsal views, carapace female, × 70. Holotype, Io. 4352. Upper Chocolate Clays (upper part), sample 24161, Zao River.

Quadracythere (Hornibrookella) sp.A

FIGS. 12–14. Left, right and dorsal views, carapace, × 70. Io. 3143. Upper Chocolate Clays (lower part), sample 24148, Zao River.

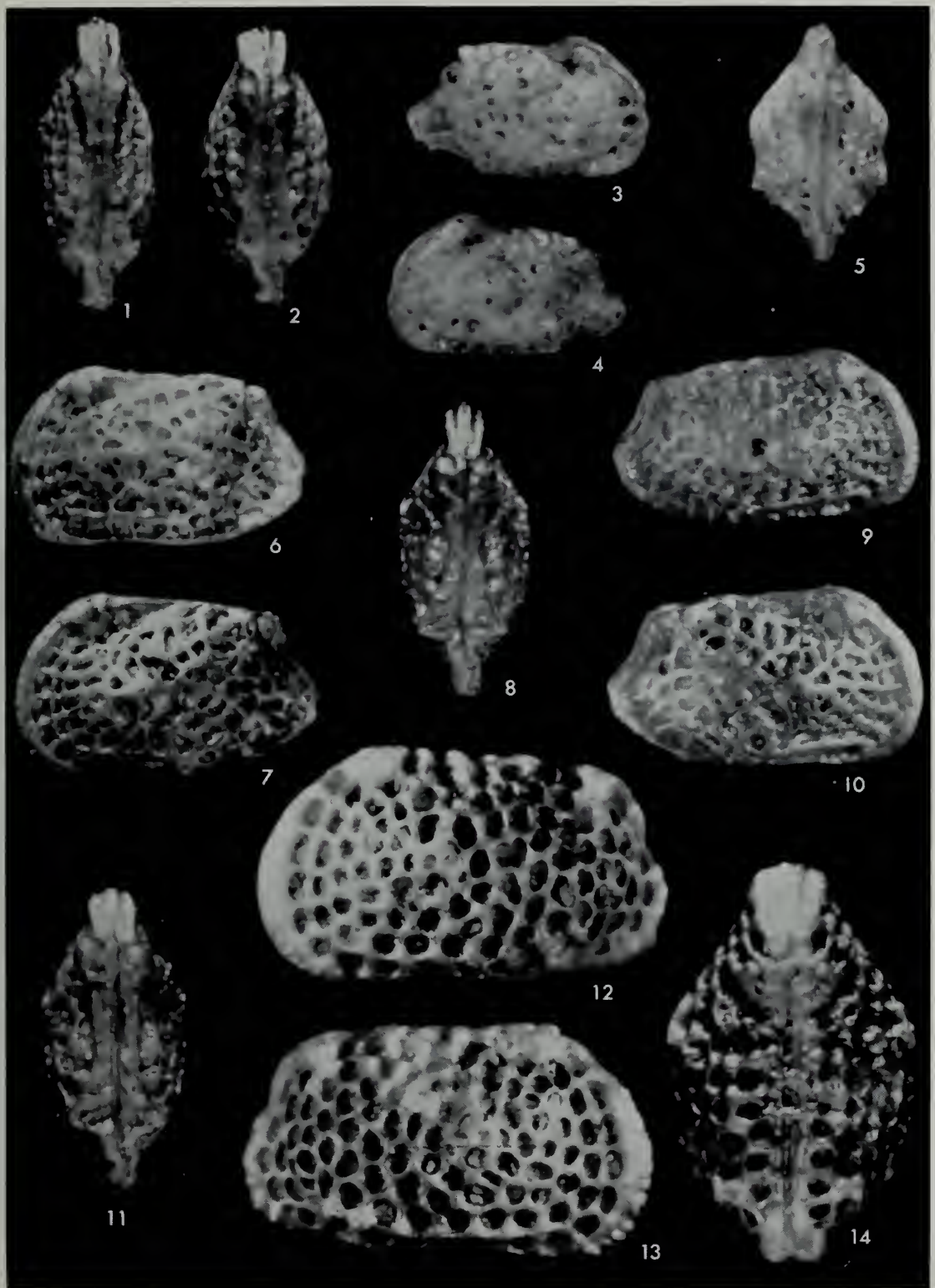
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PLATE 35

Stigmatocythere obliqua gen. et sp. nov.

FIG. 1. Dorsal view, carapace male, × 92. Specimen lost. Shales with Alabaster, sample 24173, Rakhi Nala.

FIGS. 3, 4. Left and right views, carapace male, × 92. Paratype, Io. 4303. Shales with Alabaster, sample 24173, Rakhi Nala.

FIGS. 2, 5, 6. Dorsal, left and right views, carapace female, × 92. Holotype, Io. 4355. Shales with Alabaster, sample 24173, Rakhi Nala.

FIG. 7. Dorsal view, left valve female, × 92. Paratype, Io. 3147. Shales with Alabaster, sample 24173, Rakhi Nala.

FIG. 8. Dorsal view, right valve female, × 92. Paratype, Io. 3148. Shales with Alabaster, sample 24173, Rakhi Nala.

FIG. 9. Internal view to show radial pore canals, right valve female, × 160. Paratype, Io. 3146. Shales with Alabaster, sample 24173, Rakhi Nala.

FIG. 10. Internal view to show radial pore canals, left valve female, × 160. Paratype, Io. 3149. Shales with Alabaster, sample 24173, Rakhi Nala.

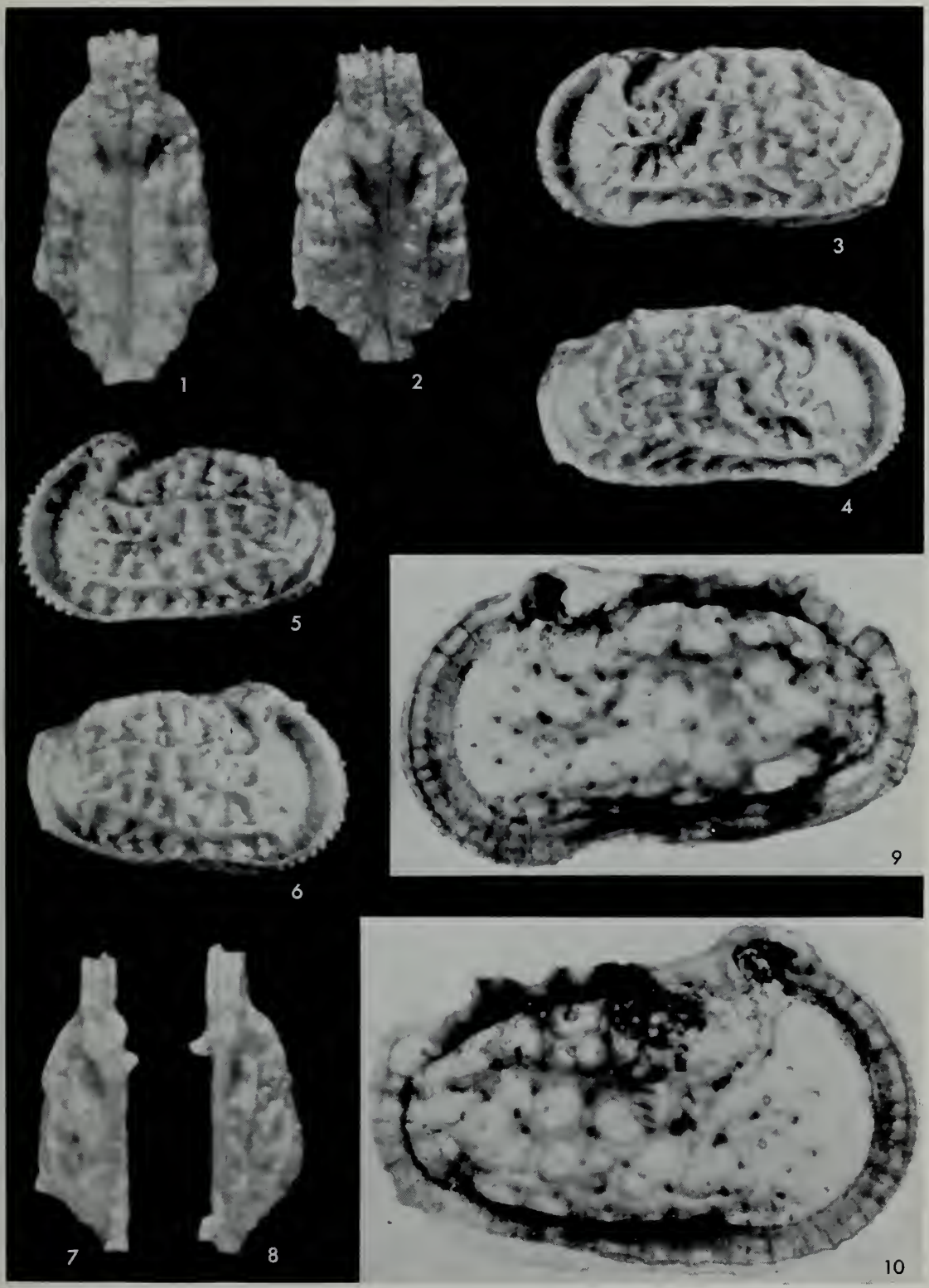
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PLATE 36

Stigmatocythere obliqua gen. et sp. nov.

FIG. 1. Ventral view, carapace male, × 92. Paratype, Io. 4303. Shales with Alabaster, sample 24173, Rakhi Nala.

FIG. 2. Ventral view, carapace male, × 92. Holotype, Io. 4355. Shales with Alabaster, sample 24173, Rakhi Nala.

Stigmatocythere portentum sp. nov.

FIGS. 3–6. Dorsal, ventral, left and right views, carapace male, × 92. Holotype, Io. 4357. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 10. Anterior radial pore canals × 216, fragment of right valve. Paratype, Io. 3144.

Stigmatocythere calia sp. nov.

FIG. 7. External view, right valve male, × 92. Paratype, Io. 3404. Upper Chocolate Clays (lower part), sample 24152, Zao River.

FIGS. 8, 9. Right and dorsal views, carapace female, × 92. Holotype, Io. 4353. Upper Chocolate Clays (lower part), sample 24151, Zao River.

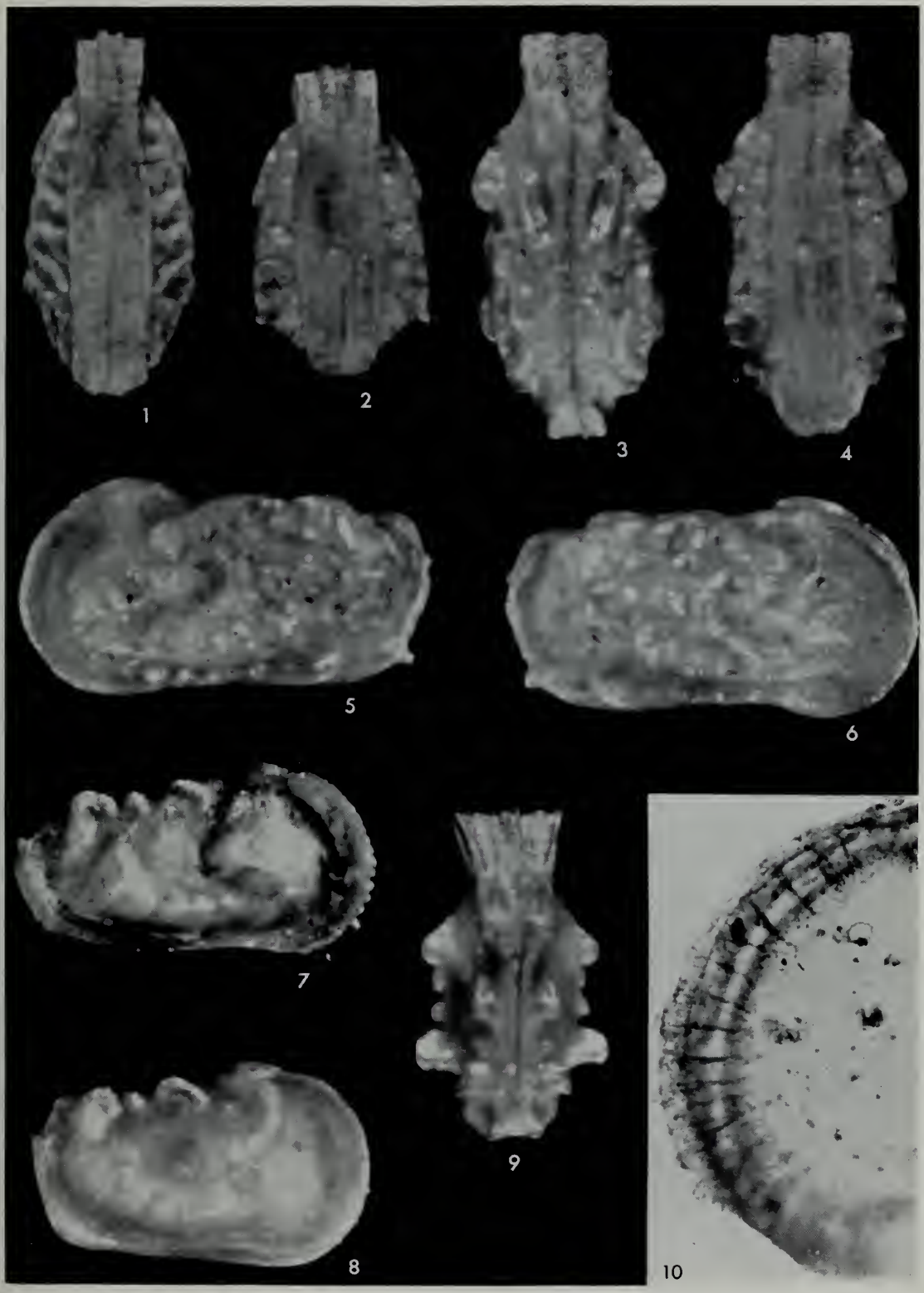
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PLATE 37

Stigmatocythere calia sp. nov.

FIGS. 1, 3. Left and ventral views, carapace female, × 92. Holotype, Io. 4353. Upper Chocolate Clays (lower part), sample 24151, Zao River.

Stigmatocythere delineata sp. nov.

FIGS. 2, 4, 5, 6. Left dorsal, right and ventral views, carapace male, × 92. Paratype, Io. 4305. Upper Chocolate Clays (lower part), sample 24154, Zao River.

FIGS. 7–10. Dorsal, left, right and ventral views, carapace female, × 92. Holotype, Io. 4356. Upper Chocolate Clays (lower part), sample 24154, Zao River.

Stigmatocythere lumaria sp. nov.

FIG. 11. Anterior radial pore canals × 150, right valve female. Paratype, Io. 3154. Upper Chocolate Clays (upper part), sample 24174, Zao River.

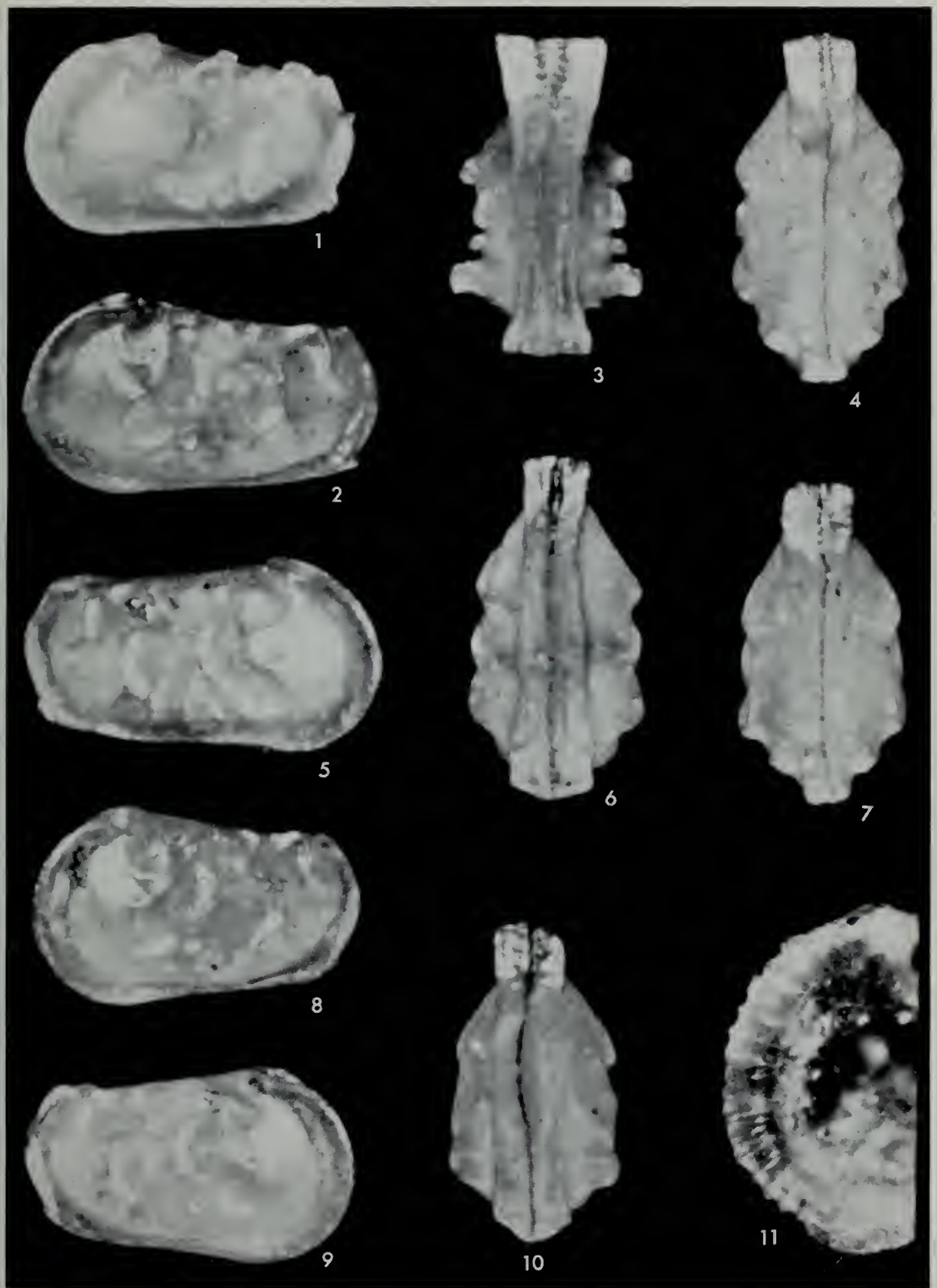
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PLATE 38

Stigmatocythere lumaria sp. nov.

Morphotype A

FIGS. 1, 5, 6. Left, dorsal and ventral views, carapace male, × 92. Holotype, Io. 4354. Upper Chocolate Clays (upper part), sample 3642, Rakhi Nala.

FIGS. 2, 4, 7. External, internal and dorsal views, right valve male, × 92. Paratype, Io. 3151. Upper Chocolate Clays (upper part), sample 3630, Rakhi Nala.

FIGS. 3, 8. External and dorsal views, right valve female, × 92. Paratype, Io. 4307. Upper Chocolate Clays (upper part), sample 3630, Rakhi Nala.

FIG. 9. Dorsal view of hinge × 240, left valve female. Paratype, Io. 3152. Upper Chocolate Clays (upper part), sample 24174, Zao River.

FIG. 10. Dorsal view of hinge × 240, right valve female. Paratype, Io. 3154. Upper Chocolate Clays (upper part), sample 24174, Zao River.

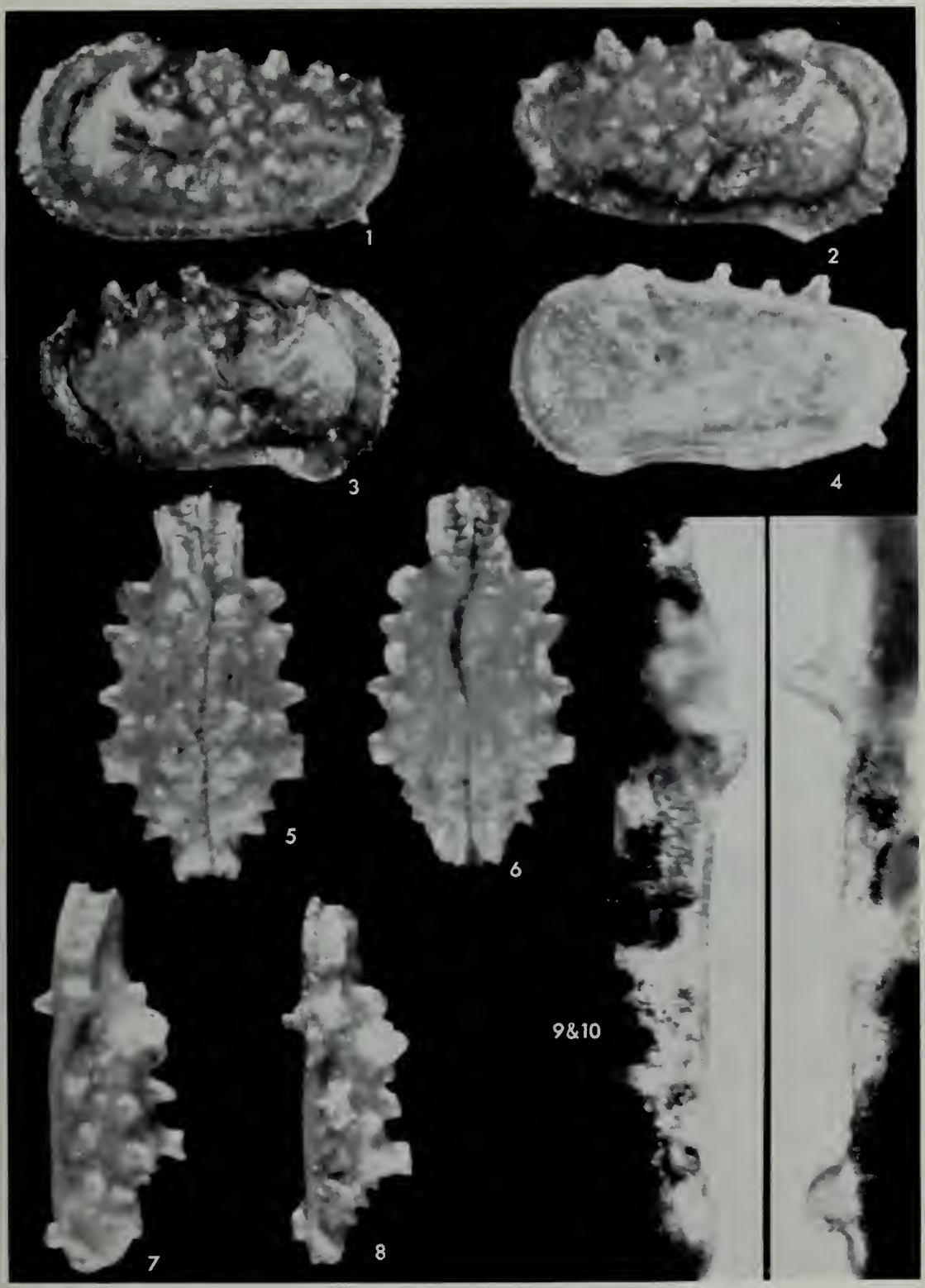
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PLATE 39

Stigmatocythere lumaria sp. nov.

Morphotype B

FIGS. 1–4. Left, right, dorsal and ventral views, carapace male, × 92. Paratype, Io. 3150. Upper Chocolate Clays (upper part), sample 3649, Rakhi Nala.

FIGS. 5–8. Left, dorsal, ventral and right views, carapace female, × 92. Paratype, Io. 3153. Upper Chocolate Clays (upper part), sample 3649, Rakhi Nala.

Morphotype A

FIG. 11. Anterior radial pore canals × 232, left valve male (juv.). Paratype, Io. 4306. Upper Chocolate Clays (upper part), sample 24174, Zao River.

Trachyleberis (Trachyleberis) lobuculus sp. nov.

FIGS. 9, 10. Left and dorsal views, carapace male, × 94. Paratype, Io. 4308. Upper Rakhi Gaj Shales, sample 3163, Rakhi Nala.

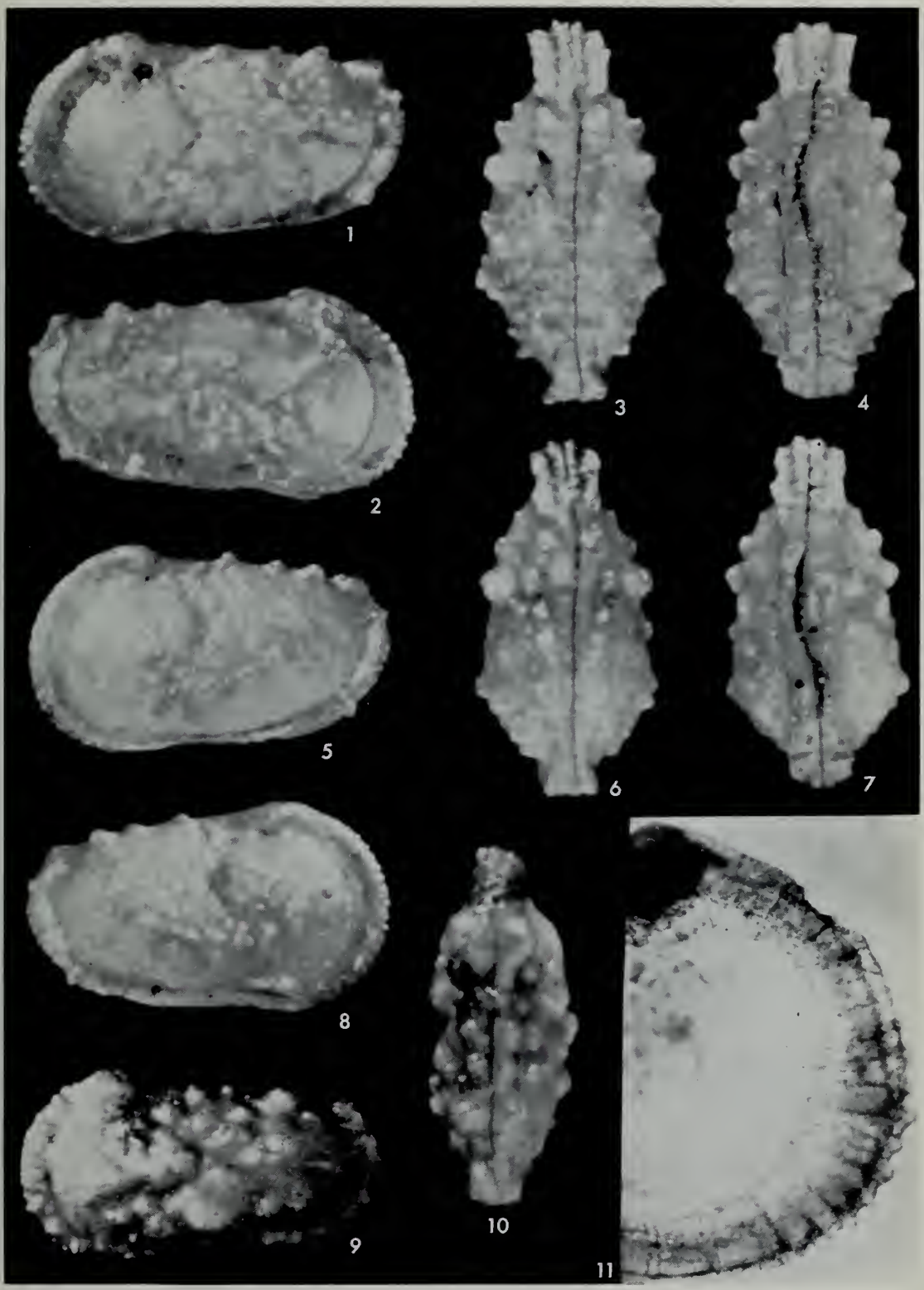
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PLATE 40

Trachyleberis (Trachyleberis) lobuculus sp. nov.

FIGS. 1, 3. Left and dorsal views, carapace female, × 93. Holotype, Io. 4364. Upper Rakhi Gaj Shales, sample 3166, Rakhi Nala.

Trachyleberis (Trachyleberis) bimammillata sp. nov.

FIGS. 2, 8, 10. Left, right and dorsal views, carapace male, × 94. Holotype, Io. 4363. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

FIG. 4. Dorsal view, left valve female, × 94. Paratype, Io. 3156. Upper Chocolate Clays (lower part), sample 3611, Rakhi Nala.

FIG. 5. Dorsal view, right valve female, × 94. Paratype, Io. 3155. Upper Chocolate Clays (lower part), sample 3614, Rakhi Nala.

FIG. 6. Dorsal view, carapace male, × 94. Paratype, Io. 3160. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

FIG. 7. Dorsal view, carapace female, × 94. Paratype, Io. 3157. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

FIG. 9. Left view, carapace female, × 94. Paratype, Io. 3159. Upper Chocolate Clays (lower part) sample 3613, Rakhi Nala.

FIG. 11. Muscle scars × 172, fragment of left valve male. Paratype, Io. 3158. Upper Chocolate Clays (lower part), sample 3613, Rakhi Nala.

Trachyleberis (Acanthocythereis) procapsus sp. nov.

FIG. 12. Left view, carapace male, × 94. Holotype, Io. 4360. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIG. 13. Left view, carapace female, × 94. Paratype, Io. 3164. Upper Palaeocene, sample 460-j, Sor Range, 8 miles east of Quetta.

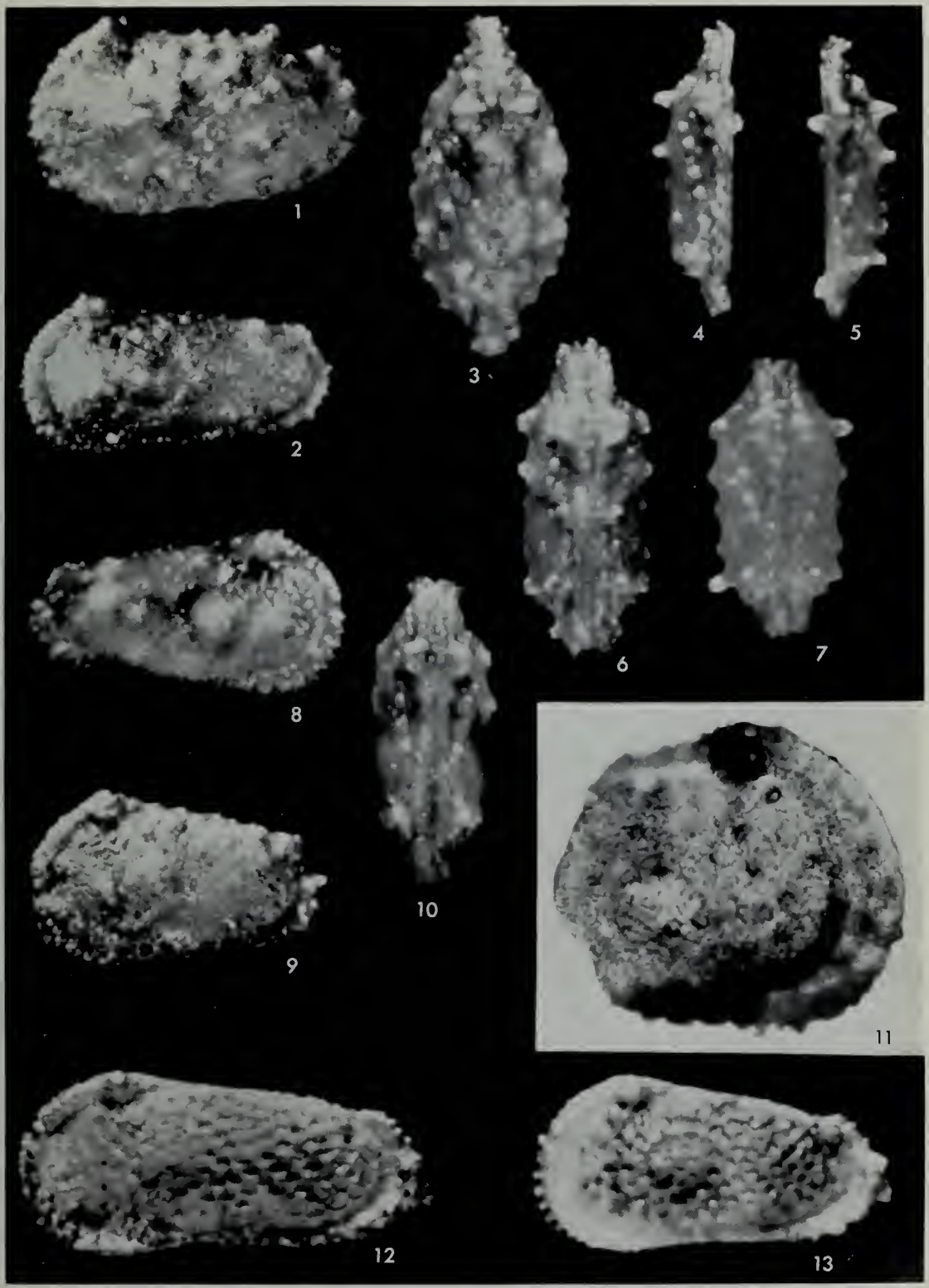
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PLATE 41

Trachyleberis (Acanthocythereis) procapsus sp. nov.

FIGS. 1, 3. Right and dorsal views, carapace male, × 94. Holotype, Io. 4360. Upper Palaeocene, sample 460-i, Sor Range, 8 miles east of Quetta.

FIG. 4. Dorsal view, carapace female, × 94. Paratype, Io. 3164. Upper Palaeocene, sample 460-j, Sor Range, 8 miles east of Quetta.

Trachyleberis (Acanthocythereis) usitata sp. nov.

FIG. 2. Right view, carapace male, × 94. Holotype, Io. 4362. Gorge Beds, sample 3111, Rakhi Nala.

FIGS. 5, 7. Left and right views, carapace female, × 94. Paratype, Io. 3161. Gorge Beds, sample 3111, Rakhi Nala.

Trachyleberis (Acanthocythereis) pedigaster sp. nov.

FIGS. 6, 8. Right and left views, carapace, × 70. Holotype, Io. 4358. Lower Rakhi Gaj Shales, sample 3671, Rakhi Nala.

Trachyleberis (Acanthocythereis) postcornis sp. nov.

FIG. 9. Left view, carapace male, × 94. Holotype, Io. 4361. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 10. Left view, carapace female, × 94. Paratype, Io. 3162. Lower Chocolate Clays, sample 3499, Rakhi Nala.

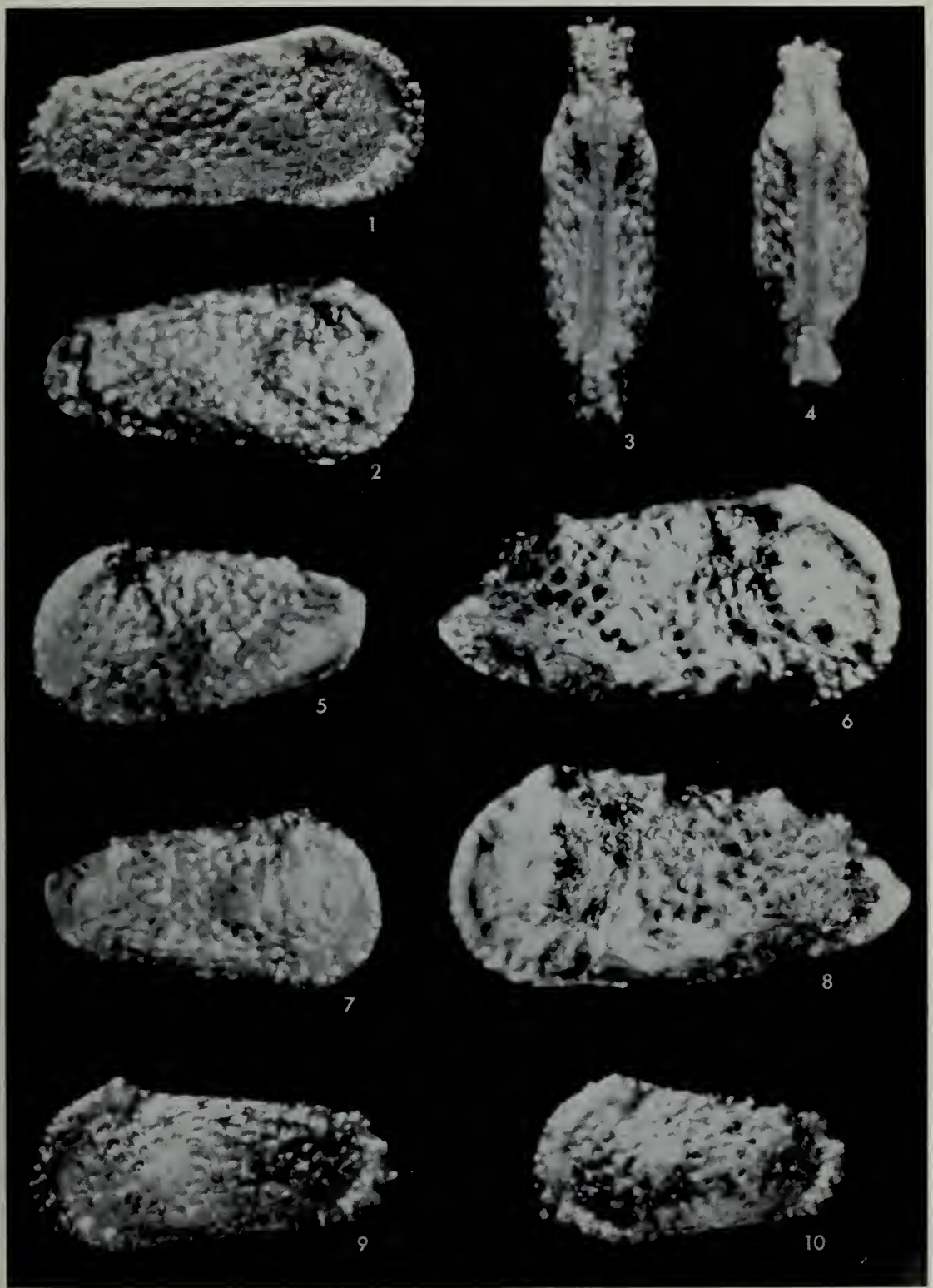
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PLATE 42

Trachyleberis (Acanthocythereis) postcornis sp. nov.

FIG. 1. Dorsal view, carapace male, × 94. Holotype, Io. 4361. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIG. 2. Dorsal view, carapace female, × 94. Paratype, Io. 3162. Lower Chocolate Clays, sample 3499, Rakhi Nala.

FIGS. 7, 10. 7, Dorsal view of hinge, × 232. 10, Internal view to show radial pore canals, × 178. Right valve female. Paratype, Io. 3163. Lower Chocolate Clays, sample 3498, Rakhi Nala.

Trachyleberis (Acanthocythereis) decoris sp. nov.

FIGS. 3–5. Dorsal, left and right views, carapace male, × 94. Holotype, Io. 4359. Upper Chocolate Clays (upper part), sample 3640, Rakhi Nala.

FIGS. 6, 8, 9. Dorsal, left and right views, carapace female, × 94. Paratype, Io. 4310. Upper Chocolate Clays (upper part), sample 3640, Rakhi Nala.

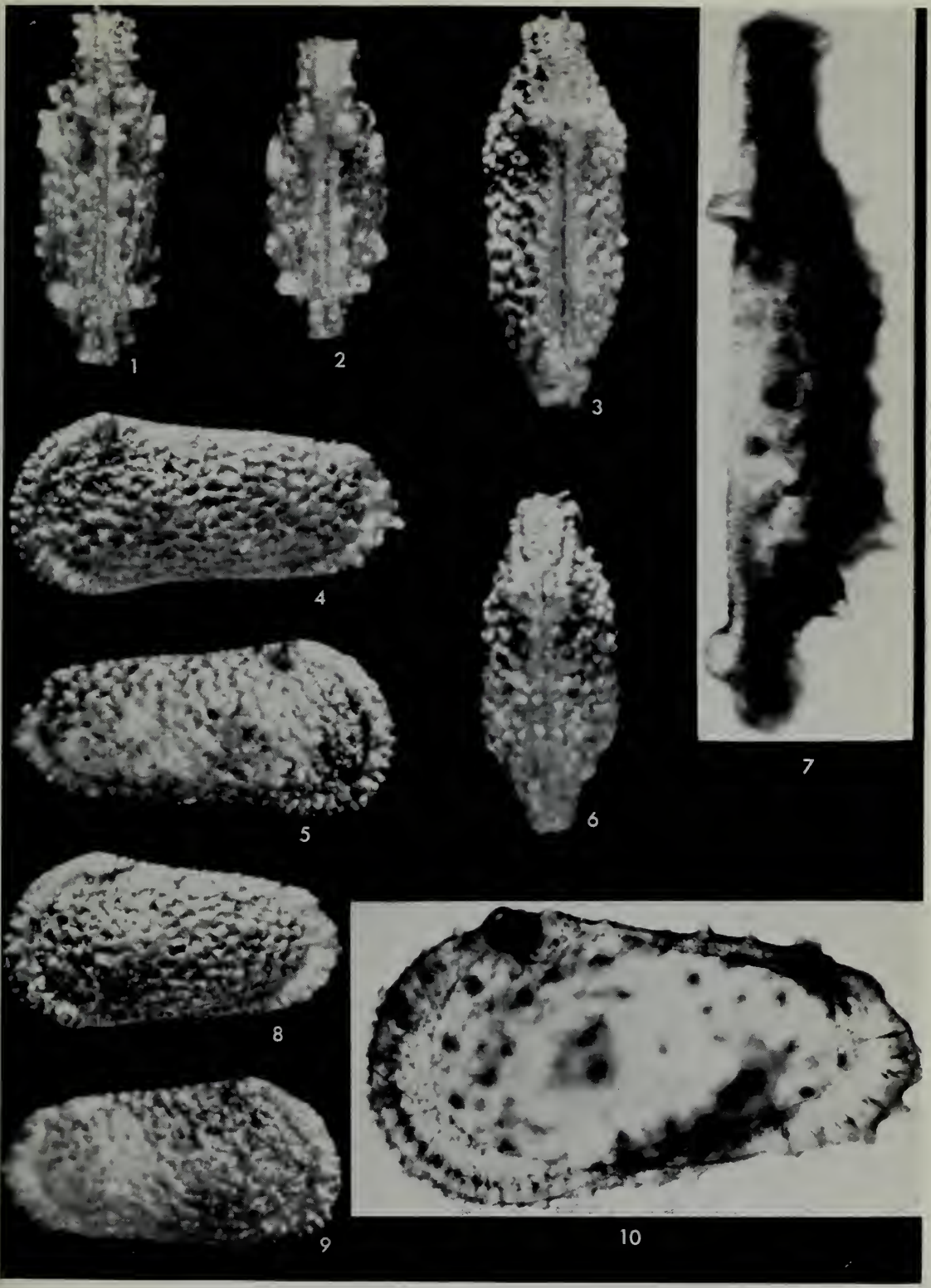
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Table 1. Stratigraphic frequency of the ostracod family Trachyleberididae in the Palaeocene and Lower Eocene of the Rakhi Nala.

Samples with total no. of ostracods (samples 3111–3182)

	Species	3111	3130	3132	3133	3672	3671	3147	3152	3153	3157	3158	3159	3160	3161	3162	3163	3164	3165	3166	3167	3168	3169	3170	3171	3172	3173	3174	3175	3176	3177	3178	3179	3180	3182
1	Alocopocythere rupina sp. nov.	41																																	
2	Buntonia devexa sp. nov.	8																																	
3	Hermanites cracens sp. nov.	1																																	
4	Trachyleberis (Acanthocythereis) usitata sp. nov.	2	1	1	1																														
5	Buntonia sp. A			2																															
6	Occultocythereis sp. A					1																													
7	Trachyleberis (Acanthocythereis) pedigaster sp. nov.						1																												
8	Alocopocythere abstracta sp. nov.							10	3	20	1	11	9	1	2	6	13	20	25	18	37	6	17	20	10	2	1	1	30	20	42	2	16	18	7
9	Trachyleberis (Trachyleberis) lobuculus sp. nov.							1	-	-	-	-	-	1	-	4	6	-	-	4	2	-	2	3	2	-	1	1	5	-	19	1	14	1	-
10	Gyrocythere parvicarinata sp. nov.									2	-	-	-	-	-	-	-	-	-	-	-	1	4	4	1	1	-	-	-	-	-	-	5	6	-
11	Phalcocythere sentosa sp. nov.									1	-	-	-	-	-	-	-	-	2	-	8	-	3	16	-	-	14	7	2	11	1	-	-	2	
12	Occultocythereis peristicta sp. nov. morphotype A													2	-	-	1	-	-	-	38	-	-	26	14	-	1	3	-	-	22	-	1		
13	Alocopocythere transcendens sp. nov.																								1	-	-	-	-	-	-	-	-	1	-
14	Occultocythereis spilota sp. nov.																										1	1	-	-	2				
15	Occultocythereis peristicta sp. nov. morphotype B																																	10	-
16	Quadracythere (Hornibrookella) directa sp. nov.																																		
17	Occultocythereis peristicta sp. nov. morphotype C																																		
18	Occultocythereis peristicta sp. nov. morphotype D																																		
19	Occultocythereis peristicta sp. nov. morphotype E																																		
20	Anommatocythere laqueta sp. nov.																																		
21	Echinocythereis (Echinocythereis) elongata sp. nov.																																		
22	Alocopocythere coarctata sp. nov.																																		
23	Alocopocythere longilinea sp. nov.																																		
24	Stigmatocythere obliqua sp. nov.																																		
25	Gyrocythere grandilaevis sp. nov.																																		
26	Phalcocythere dissenta sp. nov.																																		

Samples with total no. of ostracods (samples 3183–3423)

	Species	3183	3184	3185	3186	3187	3188	3189	3190	3191	3192	3193	3194	3195	3197	3198	3199	3200	3401	3402	3403	3404	3405	3407	3409	3410	3415	3416	3417	3418	3419	3420	3421	3422	3423
1	Alocopocythere rupina sp. nov.																																		
2	Buntonia devexa sp. nov.																																		
3	Hermanites cracens sp. nov.																																		
4	Trachyleberis (Acanthocythereis) usitata sp. nov.																																		
5	Buntonia sp. A																																		
6	Occultocythereis sp. A																																		
7	Trachyleberis (Acanthocythereis) pedigaster sp. nov.																																		
8	Alocopocythere abstracta sp. nov.	7	5	-	50	10	45	70	70	85	-	220	250	40	55	30	55	100	35	32	38	30	18	190	22	42	5	3	33	55	40	10	170	68	55
9	Trachyleberis (Trachyleberis) lobuculus sp. nov.	2	3	1	14	5	2	18	15	15	9	33	-	-	8	2	6	11	7	2	7	5	-	2	2	7	2	-	2	2	11	3	2	7	-
10	Gyrocythere parvicarinata sp. nov.	-	-	1	-	-	-	-	-	-	2	3	-	-	-	-	5	11	3	5	5	14	7	20	15	3	3	-	1						
11	Phalcocythere sentosa sp. nov.																																		
12	Occultocythereis peristicta sp. nov. morphotype A																																		
13	Alocopocythere transcendens sp. nov.	-	-	-	-	-	-	3	2	10	-	4	13	-	20	7	6	10	4	3	4	4	5	26	3	4	-	-	-	8	8	3	14	7	10
14	Occultocythereis spilota sp. nov.																																		
15	Occultocythereis peristicta sp. nov. morphotype B	-	-	-	21	1	1	38	18	19	2	91	42	-	8	3	3	33	11	12	14	4	3	1	-	10	1	-	-	22	11	1	23	12	14
16	Quadracythere (Hornibrookella) directa sp. nov.		1	-	-	-	-	-	-	-	57	-	-	-	-	-	-	-	-	7	31														
17	Occultocythereis peristicta sp. nov. morphotype C				9	-	-	31	15	41	2	1	-	-	-	-	-	-	-	5	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	Occultocythereis peristicta sp. nov. morphotype D				2	2	-	11	1	21	-	-	1	-	-	-	-	-	-	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	Occultocythereis peristicta sp. nov. morphotype E											3	11	-	5	1	1	17	2	3	2	1	3	-	-	10	1	-	-	4	13	-	5	4	-
20	Anommatocythere laqueta sp. nov.																				4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	Echinocythereis (Echinocythereis) elongata sp. nov.																					5	-	-	1	-	-	3							
22	Alocopocythere coarctata sp. nov.																																		
23	Alocopocythere longilinea sp. nov.																																		
24	Stigmatocythere obliqua sp. nov.																																		
25	Gyrocythere grandilaevis sp. nov.																																		
26	Phalcocythere dissenta sp. nov.																																		

Samples with total no. of ostracods (samples 3424–3473)

	Species	3424	3426	3428	3429	3432	3434	3435	3438	3440	3443	3444	3445	3446	3447	3448	3450	3451	3452	3453	3454	3456	3457	3458	3459	3460	3461	3462	3463	3464	3465	3466	3467	3470	3473
1	Alocopocythere rupina sp. nov.																																		
2	Buntonia devexa sp. nov.																																		
3	Hermanites cracens sp. nov.																																		
4	Trachyleberis (Acanthocythereis) usitata sp. nov.																																		
5	Buntonia sp. A																																		
6	Occultocythereis sp. A																																		
7	Trachyleberis (Acanthocythereis) pedigaster sp. nov.																																		
8	Alocopocythere abstracta sp. nov.	30	75	205	55	45	40	90	175	-	19	-	7																						
9	Trachyleberis (Trachyleberis) lobuculus sp. nov.	-	-	1	1	-	11	1																											
10	Gyrocythere parvicarinata sp. nov.																																		
11	Phalcocythere sentosa sp. nov.																																		
12	Occultocythereis peristicta sp. nov. morphotype A																																		
13	Alocopocythere transcendens sp. nov.	1	23	2	13	9	10	29	6	-	-	-	-	-	-	-	-	-	-	-	-	-	100	131	1	-	-	-	-	-	-	-	-	-	-
14	Occultocythereis spilota sp. nov.																																		
15	Occultocythereis peristicta sp. nov. morphotype B	-	-	3	-	-	12	7																											
16	Quadracythere (Hornibrookella) directa sp. nov.																																		
17	Occultocythereis peristicta sp. nov. morphotype C	-	-	-	-	-	-	5																											
18	Occultocythereis peristicta sp. nov. morphotype D	-	-	-	-	-	-	5																											
19	Occultocythereis peristicta sp. nov. morphotype E	-	-	-	-	1	4	3																											
20	Anommatocythere laqueta sp. nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	26			
21	Echinocythereis (Echinocythereis) elongata sp. nov.																																		
22	Alocopocythere coarctata sp. nov.					4	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39	1										
23	Alocopocythere longilinea sp. nov.								9	60	75	105	10	-	-	80	80	1	-	-	-	-	18	300											
24	Stigmatocythere obliqua sp. nov.															23	-	3	2	1	25	145	22	-	-	35	48	35	24	170	230	80	30	1	480
25	Gyrocythere grandilaevis sp. nov.																												10	4	1	1			
26	Phalcocythere dissenta sp. nov.																			1	30	-	-	-	210	135	50	-	70						

NO OSTRACODS

NO OSTRACODS

G.B. | L.R.G.S. | Upper Rakhi Gaj Shales | Green and Nodular Shales | Rubbly Limestones | Shales with Alabaster

RA. | G H A Z I J

PAL. | L O W E R E O C E N E

L.R.G.S. = Lower Rakhi Gaj Shales
G.B. = Gorge Beds
RA. = Ranikot
PAL. = Palaeocene

Table 2. Stratigraphic frequency of the ostracod family Trachyleberididae in the Middle and Upper Eocene of the Rakhi Nala.

	Species \ Samples with total no. of ostracods	3498	3499	3604	3607	3608	3609	3610	3611	3613	3614	3615	3617	3618	3620	3621	3622	3623	3624	3625	3626	3627	3628	3629	3630	3631	3634	3640	3641	3642	3645	3646	3647	3648	3649	3650	3651	3652	3653	3658	3660	3661	3662	3663	3664
	NO OSTRACODS			14																																								
1	Alocopocythere transcendens sp. nov.	58	19	-	2	1	-	1	-	-	2	2	7	3																															
2	Gyrocythere perfecta sp. nov.	5	15																																										
3	Stigmatocythere portentum sp. nov.	1	7																																									
4	Trachyleberis (Acanthocythereis) postcornis sp. nov.	12	33																																									
5	Anommatocythere confirmata sp. nov.		12	-	-	-	-	-	3	6	17	32																																
6	Echinocythereis (Scelidocythereis) rasilis sp. nov.		12	-	-	-	-	-	-	-	3	-	2																															
7	Hermanites scopus sp. nov.		1	-	-	-	-	4	-	4	1	1	-	2																														
8	Occultocythereis indistincta sp. nov.		2	-	-	-	-	-	-	-	1	1	-	-	-	1	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	31								
9	Quadracythere (Hornibrookella) arcana (Lubimova & Guha)		2																																								
10	Costa (Paracosta) compitalis sp. nov.			3	2	-	8	2	2	10	6	5	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	6	-	6	5	-	-	6	38	2	-	-	-	-	-	51	6	9	10
11	Trachyleberis (Acanthocythereis) decoris sp nov.							1	13	5	2	2	2	3	1																														
12	Actinocythereis? quasibathonica sp. nov.							4		25	2	6	5																																
13	Trachyleberis (Trachyleberis) bimammillata sp. nov.									7	1																																		
14	Gyrocythere exaggerata sp. nov.									3	3	1	1	1																															
15	Hermanites palmatus sp. nov.															14	-	-	13	1																									
16	Echinocythereis (Scelidocythereis) multibullata sp. nov.															2	-	-	2	2	8	1	6	-	5	-	-	6	5	1	13	6	1	23	42	38	6	-	-	1	-	-	5	34	
17	Stigmatocythere lumaria sp. nov. morphotype A.															2	2																												
18	Costa (Paracosta) disintegrata sp. nov.																		14	5	-	-	5	-	-	3	1	3	3	5	8	1	-	-	8	-	-	-	-	5	-	-	2			
19	Patagonacythere? nidulus sp. nov.																		3	5	8	-	2	-	12	2																			
20	Alocopocythere transversa sp. nov. morphotype A																			3	5	-	-	-	3																				
21	Alocopocythere transversa sp. nov. morphotype B																									2	4	1	-	4	-	-	1	2	2	1								
22	Alocopocythere transversa sp. nov. morphotype C																										7	1	-	-	-	-	2	2	18	3	14	3					
23	Alocopocythere transversa sp. nov. morphotype D																										1	-	2	5	-	-	1	11		1	20		21	63			
24	Alocopocythere transversa sp. nov. morphotype E																										1	-	-	6	2	-	14	12	46	1	47						
25	Stigmatocythere lumaria sp. nov. morphotype B																														1	-	-	8	30	-	35	2					
26	Alocopocythere transversa sp. nov morphotype F																																				14						
27	Alocopocythere radiata sp. nov.																																									7	19	6	2
28	Costa (Paracosta) declivis sp. nov.																																											

W.M.B = White Marl Band
L.C.C = Lower Chocolate Clays
P.L = Platy Limestone

P.L. | L.C.C. | W.M.B | Upper Chocolate Clays Lower part | Upper Chocolate Clays Upper part | Pellatispira Beds

LOWER KIRTHAR (= Kirthar sensu stricto of Eames.) | UPPER KIRTHAR (= Tapti of Eames.)

MIDDLE EOCENE | UPPER EOCENE

Table 3. Stratigraphic frequency of the ostracod family Trachyleberididae in the Eocene of the Zao River.

	Species \ Samples with total no. of ostracods	24107	24110	24123	24127	24131	24132	24145	24147	24148	24150	24151	24152	24153	24154	24155	24156	24157	24159	24161	24166	24170	24173	24174	24175	24176	24177	24178	24180	24181	24183	24184	24185	24186	24187	24188	24191	24193	24195
1	Anommatocythere laqueta sp. nov.	2																																					
2	Phalcocythere dissenta sp. nov.	6																																					
3	Stigmatocythere obliqua sp. nov.	440	30																																				
4	Alocopocythere transcendens sp.nov.			14	20	50	35	1	9	30	35	30	39																										
5	Gyrocythere mitigata sp. nov.					8	1																																
6	Hermanites palmatus sp.nov.					2	-	-	-	-	2	-	4	-	-	-	9																						
7	Trachyleberis (Acanthocythereis) postcornis sp.nov.					1	-	-	-	2																													
8	Anommatocythere confirmata sp.nov.							3	1	16	24	3	6																										
9	Echinocythereis (Scelidocythereis) rasilis sp.nov.							6	4	11	3	-	5	2	-	-	-	10																					
10	Gyrocythere exaggerata sp.nov.							1	3	15	8	11	1																										
11	Hermanites scopus sp nov.									1	1																												
12	Quadracythere (Hornibrookella) sp. A.									1																													
13	Stigmatocythere calia sp. nov.									3	2	1	8	1																									
14	Actinocythereis ? quasibathonica sp nov.										9	-	-	-	1																									
15	Trachyleberis (Trachyleberis) bimammillata sp.nov.										3	-	4																										
16	Patagonacythere?nidulus sp.nov.										2	-	-	-	-	5	6	24	17	-	1	14	112	-	56	1	7	4	100	-	64	-	1	-	1	-	-	4		
17	Echinocythereis (Scelidocythereis) multibullata sp.nov.														12	-	3	-	8	51	-	-	-	-	-	-	-	-	-	-	2								
18	Stigmatocythere delineata sp.nov.														3	3																							
19	Trachyleberis (Acanthocythereis) decoris sp. nov.														1	-	-	-	-	-	-	6																	
20	Alocopocythere transversa sp.nov. morphotype A.															15	-	-	1																				
21	Alocopocythere transversa sp nov. morphotype B.															3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
22	Stigmatocythere lumaria sp.nov. morphotype A																4	12	4	-	-	16	19	6	6	1	-	-	1	-	-	2	-	-	7	-	-	1
23	Alocopocythere transversa sp.nov. morphotype E.																	2	-	-	-	8	96	4	15	2	15	18	84	5	29	168	3	33	20				
24	Alocopocythere transversa sp. nov. morphotype C.																		1	-	-	1	1	-	5	10	1	-	64	13	10	-	5	-	-	6			
25	Bradleya ? voraginosa sp.nov.																		3	7																			
26	Echinocythereis (Scelidocythereis) sparsa sp.nov.																		16	-	-	-	-	-	-	-	-	-	14	13									
27	Phalcocythere spinosa sp. nov.																			16																			
28	Quadracythere (Hornibrookella) subquadra sp.nov.																			41																			
29	Alocopocythere transversa sp. nov. morphotype D.																					12	18	11	16	-	-	-	-	-	-	-	-	-	10				
30	Alocopocythere transversa sp.nov. morphotype F																					5	49	15	23	10													
31	Alocopocythere radiata sp.nov.																						8																

NO OSTRACODS

NO OSTRACODS

S.W.A. = Shales with Alabaster

P.L. = Platy Limestone

L.C.C. = Lower Chocolate Clays

W.M.B. = White Marl Band

S.W.A. | P.L. | L.C.C. | W.M.B. | Upper Chocolate Clays. Lower part | Upper Chocolate Clays Upper part

GHAZIJ | LOWER KIRTHAR (= Kirthar s.s. of Eames) | UPPER KIRTHAR (= Tapti of Eames)

Lr. EOC. | MIDDLE EOCENE | UPPER EOCENE

TABLE 4. DISTRIBUTION CHART OF OSTRACODA IN THE PALAEOCENE AND EOCENE OF THE RAKHI NALA

OSTRACOD SPECIES	GORGE BEDS	LOWER RAKHI NALA SHALES	UPPER RAKHI GAJ SHALES	GREEN & NODULAR SHALES	RUBBLY LIMESTONES	SHALES WITH ALABASTER	LOWER CHOCOLATE CLAYS	UPPER CHOCOLATE CLAYS (lower part)	UPPER CHOCOLATE CLAYS (upper part)	PELLATISPIRA BEDS
	PALAEOCENE		LOWER EOCENE				MID EOCENE		UP EOCENE	
*	I	II	III			IV	V			
Alocopocythere rupina	•									
Bairdia sp.A	•									
Buntonia devexa	•									
Cytherella sp.A	•									
Hermanites cracens	•									
Neocyprideis ? sp.A	•									
Genus A sp.1	•									
T.(Acanthocythereis) usitata	•	•								
Brachycythere sp.A		•								
Buntonia sp.A		•								
Bythocypris sp.A		•								
Krithe sp.A		•								
Occultocythereis sp.A		•								
T.(Acanthocythereis) pedigaster		•								
Genus A sp.2		•								
Cytheropteron sp.B			•	•						
Occultocythereis peristicta A			•	•						
Phalocythere sentosa			•	•						
Pontocyprella sp.A			•	•						
Gyrocythere parvicarinata			•	•	•					
Krithe sp.B			•	•	•					
Pontocythere sp.A			•	•	•					
T.(Trachyleberis) lobuculus			•	•	•					
Alocopocythere abstracta			•	•	•	•				
Genus B sp.1			•	•	•	•				
Cytherella sp.B			•	•	•	•				
Paijenborchellina sp.A			•	•	•	•				
Paracypris sp.A			•	•	•	•				
Xestoleberis sp.A			•	•	•	•				
Occultocythereis spilota				•						
Q.(Hornibrookella) directa				•						
Cytherella sp.A				•	•					
Cytherelloidea sp.A				o	•					
Occultocythereis peristicta B				•	•					
Occultocythereis peristicta C				•	•					
Occultocythereis peristicta D				•	•					
Occultocythereis peristicta E				•	•					
Paracypris sp.B				•	•					
Schizocythere sp.A				•	•					
Anommatocythere laqueta				•		•				
Bairdia sp.B				•		•				
Bairdia sp.C				•		•				
Uroleberis sp.A				•		•				
Xestoleberis sp.B				•		•				
Alocopocythere transcendens				•	•	•	•	•		
Cytherelloidea sp.B					•					
E.(Echinocythereis) elongata					•					
Alocopocythere longilinea					•	•				
Alocopocythere coarctata					•	•				
Cytheropteron sp.A					•	•				
Paijenborchella sp.A					•	•				
Aglaiocypris sp.A						•				
Bairdia sp.C						•				
Bythocypris sp.A						•				
Cytherella sp.C						•				
Cytherella sp.D						•				
Eucytherura sp.B						•				
Gyrocythere grandilaevis						•				
Neocyprideis ? sp.B						•				
Neocyprideis sp.C						•				
Phalocythere dissenta						•				
Pontocyprella sp.B						•				
Pontocyprella sp.C						•				
Stigmatocythere obliqua						•				
Uroleberis sp.B						•				
Xestoleberis sp.C						•				
Xestoleberis sp.D						•				
Xestoleberis sp.E						•				
Xestoleberis sp.F						•				
Genus C sp.1						•				
Genus C sp.2						•				
Cytherelloidea sp.C							•			
Gyrocythere perfecta							•			
Paijenborchella sp.B							•			
Q.(Hornibrookella) arcana							•			
Stigmatocythere portentum							•			
T.(Acanthocythereis) postcornis							•			
Paracypris sp.C							•			
Anommatocythere confirmata							•	•		
Genus B sp.2							•	•		
Cytherella sp.E							•	•		
Cytherelloidea sp.D							•	•		
Cytheropteron sp.C							•	•		
E.(Scelidocythereis) rasilis							•	•		
Hermanites scopus							•	•		
Krithe sp.C							•	•		
Schizocythere sp.B							•	•		
Bairdia sp.A							•	•	•	
Cytherella sp.G							•	•	•	
Cytherelloidea cf.C.costatruncata							•	•	•	
Cytheromorpha sp.A							•	•	•	
Cytheropteron sp.D							•	•	•	
Krithe sp.E							•	•	•	
Occultocythereis indistincta							•	•	•	
Xestoleberis sp.G							•	•	•	
Cytherelloidea sp.F							•	•	•	o
Paijenborchella sp.C							•	•	•	
Actinocythereis ? quasibathonica								•		
Aglaiocypris sp.C								•		
Bythoceratina sp.A								•		
C.(Paracosta) compitalis								•		
C.(Paracosta) disintegerata								•		
E.(Scelidocythereis) multibullata								•		
Gyrocythere exaggerata								•		
Hermanites palmatus								•		
Propontocypris sp.A								•		
T.(Trachyleberis) bimammillata								•		
Uroleberis sp.C								•		
Uroleberis sp.D								•		
Alocopocythere transversa A								•	•	
Alocopocythere transversa B								•	•	
Cytherella sp.F								•	•	
Paracypris sp.D								•	•	
Paracypris sp.E								•	•	
Polycope sp.A								•	•	
P.(Pterygocythere) sp.A								•	•	
Krithe sp.D								•	•	•
Paijenborchella sp.D								•	•	o
Paijenborchella sp.E								•	•	•
Patagonacythere ? nidulus								•	•	•
Stigmatocythere lumaria A								•	•	•
T.(Acanthocythereis) decoris								•	•	•
Alocopocythere transversa C									•	
Alocopocythere transversa D									•	
Alocopocythere transversa F									•	
Alocopocythere radiata									•	
Stigmatocythere lumaria B									•	
Cytherelloidea sp.E									•	•
Cytherelloidea sp.G									•	•
Alocopocythere transversa E									•	•
C.(Paracosta) declivis										•
Krithe sp.G										•
Neocyprideis ? sp.D										•
Paijenborchella sp.F										•
Pontocythere sp.B										•

*Ostracod Biostratigraphic Units (I–V)

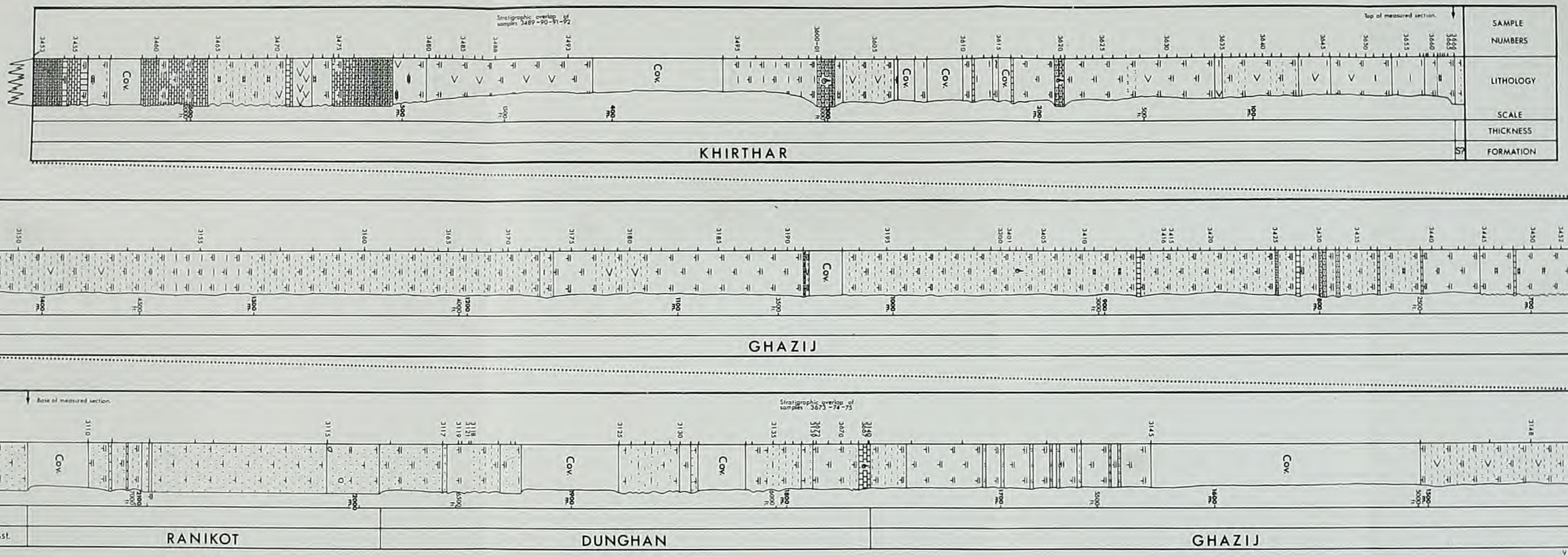
o doubtful

TABLE 5 DISTRIBUTION CHART OF OSTRACODA IN THE EOCENE OF THE ZAO RIVER.

OSTRACOD SPECIES	SHALES WITH ALABASTER	LOWER CHOCOLATE CLAYS	UPPER CHOCOLATE CLAYS (lower part)	UPPER CHOCOLATE CLAYS (upper part)
	LR. EOCENE	MIDDLE	EOCENE	UP. EOCENE
	IV	V		
Anommatocythere laqueta	•			
Bairdia sp. C	•			
Bairdia sp. D	•			
Cytherella sp. B	•			
Cytherella sp. C	•			
Neocyprideis sp. B	•			
Neocyprideis sp. C	•			
Paracypris sp.	•			
Phalcocythere dissenta	•			
Pontocyprella sp. B	•			
Pontocyprella sp. C	•			
Stigmatocythere obliqua	•			
Xestoleberis sp. C	•			
Xestoleberis sp. D	•			
Xestoleberis sp. E	•			
Genus C sp. 1	•			
Genus C sp. 2	•			
Gyrocythere mitigata		•		
Paijenborchella sp. C		•		
Pontocyprella sp. D		•		
Xestoleberis sp. H		•		
Alocopocythere transcendens		•	•	
Cytherella sp. E		•	•	
Cytheropteron sp. C		•	•	
Hermanites palmatus		•	•	
Schizocythere sp. B		•	•	
T.(Acathocythereis) postcornis		•	•	
Bairdoppilata sp. A		•	•	•
Cytherella sp. F		•	•	•
Cytherella sp. G		•	•	•
Cytherelloidea cf. C. costatruncata		•	•	•
Cytherelloidea sp. F		•	•	•
Cytheromorpha sp. A		•	•	•
Paijenborchella sp. C		•	•	•
Actinocythereis ? quasibathonica			•	
Alocopocythere transversa A			•	
Anommatocythere confirmata			•	
Genus B sp. 2			•	
Cytherelloidea cf. Cytherelloidea sp. C			•	
E.(Scelidocythereis) rasilis			•	
Gyrocythere exaggerata			•	
Hermanites scopus			•	
Paracypris sp. G			•	
Pontocythere sp. G			•	
Q.(Hornibrookella) sp. A			•	
Stigmatocythere calia			•	
Stigmatocythere delineata			•	
T.(Trachyleberis) bimammillata			•	
Aglaiocypris sp. B			•	•
Alocopocythere transversa C			•	•
Alocopocythere transversa D			•	•
Alocopocythere transversa E			•	•
Bairdia sp. D			•	•
Bradleya ? voraginosa			•	•
Cytheropteron sp. D			•	•
E.(Scelidocythereis) sparsa			•	•
E.(Scelidocythereis) multibullata			•	•
Krithe sp. D			•	•
Krithe sp. E			•	•
Paijenborchella sp. E			•	•
Patagonacythere ? nidulus			•	•
P.(Pterygocythere) sp. A			•	•
Stigmatocythe lumaria A			•	•
T.(Acanthocythereis) decoris			•	•
Xestoleberis sp. G			•	•
Alocopocythere transversa E				•
Alocopocythere transversa F				•
Alocopocythere radiata				•
Cytherelloidea sp. E				•
Krithe F				•
Neocyprideis ? sp. D				•
Neocyprideis ? sp. E				•
Paijenborchella sp. F				•
Paracypris sp. F				•
Phalcocythere spinosa				•
Q.(Hornibrookella) subquadra				•
Stigmatocythere lumaria				•

* Ostracod Biostratigraphic Units (IV–V)

Rakhi Nala Stratigraphic Section, measured by S.L.Rieb and sampled by D.D.Bayliss. 1957.



LEGEND

- Sand
- Sandstone
- Conglomeratic sandstone
- Silt
- Siltstone
- Siltstreaks
- Mudstone
- Shale
- Argillaceous formation
- Shale or clay lenses
- Marl
- Limestone
- Coquina or fossiliferous limestone
- Argillaceous limestone
- Calcareous streaks or lenses
- Gypsum

ABBREVIATIONS

Cov.	Covered
S?	Siwalik
Pab sst.	Pab Sandstone

SCALE: Feet and Metres.
0·5 inches = 100 feet.
4·2 cms. = 100 metres.

N.B. Sample numbers for every fifth sample unless otherwise indicated.

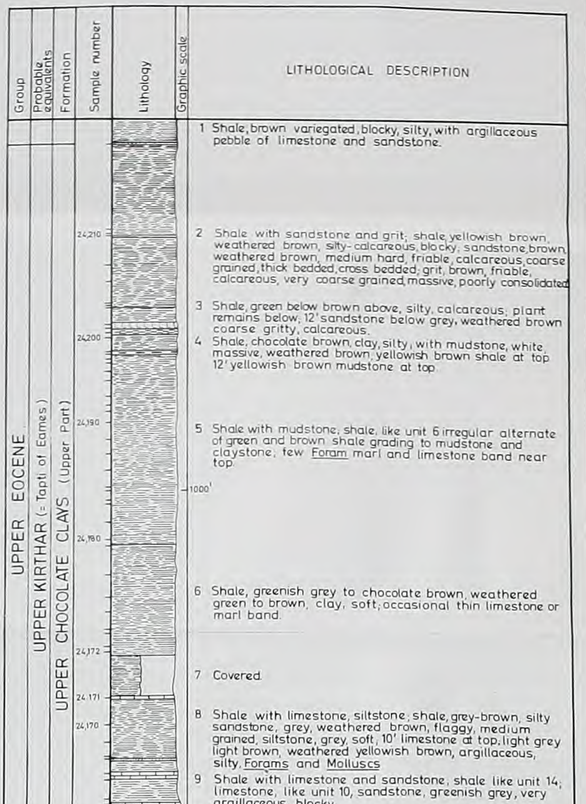
ZAO RIVER SECTION

Measured by

S.M. Ahmed & W.A. Zuberi.

Scale 0 200 Feet

0 20 40 Metres



SHPALAI KHWARA SECTION.

(Uppermost part)

Measured by

S.M. Ahmed & W.A. Zuberi.

Scale 0 200 Feet

0 20 40 Metres